People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

Abdelhamid Ibn Badis University
Mostaganem

Faculty of Natural and

Life Sciences

UNIVERSITE
Abdelhamid Ibn Badis
MOSTAGANEM

جامعة عبد الحميد بن باديس

مستغانم

كلية علوم الطبيعة و الحياة

Handout of :

Hygiene and Safety in Dairy Production and Processing

By: **MENAD Najett**

2025 – 2026

FOREWORD

Hygiene and Safety in Dairy Production and Processing Course for third-year undergraduate students (LMD system), specializing in Dairy Production and Processing (PTL) at Abd El Hamid Ibn Badis University, Mostaganem.

Language of instruction: English

Teaching unit: Discovery (UED)

Semester: 5 ; **Credits:** 2 ; **Coefficient:** 2

Objective:

Define a hygiene policy that involves cleaning, disinfecting, and sanitizing equipment, surfaces, premises, and personnel, and implement and monitor it in accordance with current standards and regulations.

- Apply hygiene principles in the food industry (Codex Alimentarius, HACCP, ISO 22000);
- Carry out sanitation and pest control interventions;
- Practice hygiene (rodent control, insect control, and disinfection);
- Control hand flora;
- Apply microorganism destruction and elimination scales;
- Ensure the principles of detergents and disinfection;
- Master "Cleaning in Place";
- Ensure surface disinfection by air.

Recommended prior knowledge:

Prerequisites for this module include sufficient knowledge of the following subjects: Food and Basic Food Technology, Food Microbiology, and Food Technology and Quality.

Tutorials:

The objective is to master the important principles of hygiene and safety in dairy production and processing and to learn how to apply these principles in tutorials. The tutorials will consist of:

- Exercises illustrating each chapter;
- Case studies covering the various points covered in class.

Assessment method:

Continuous assessment, Presentations, Posters, Tutorial report.

Content of the material

Introduction

In today's modern business environment, implementing a hygiene, safety, and environmental (HSE) policy is essential given the many challenges involved. Dairy companies are showing growing interest in health, safety, and the environment. First, there is a more rigorous implementation of legislation (labor code). It is the manager's responsibility to ensure the physical safety of employees, their safety, and the protection of the environment. Companies understand the importance of an HSE policy, as its effectiveness helps minimize the risk of accidents and environmental damage (population, water, soil, fauna, and flora).

It also offers benefits: economic by reducing expenses associated with workplace accidents and occupational diseases as well as sick leave; social such as improved social communication, internal communication, company image, and sustainability; working in optimal conditions and in a healthy environment. As a result, the HSE policy, which is incorporated into all activities from the design phase, helps prevent accidents or catastrophic incidents while ensuring social responsibility and economic competitiveness.

Safety refers to the absence of accidents or risks deemed unacceptable. The accident represents a materialization of the risk that can cause harm to individuals, equipment, and/or the environment. That is what we are concerned about in this document to develop a strategy within professional activities. The objective of this policy is to implement actions aimed at preventing and protecting the health of employees and communities, while preserving facilities and the environment.

Chapter I: Hygiene-Safety

I.1. Introduction

The management of hygiene, health, and safety at work now plays an increasingly crucial role in business strategy and management, as beside the human and social tragedy caused by a workplace accident (WA) or an occupational disease.

To protect lives within a company, criminal measures have been recently strengthened, potentially leading to civil, or even criminal, liability for the company's manager. The intention is to make him aware of his role. A key player in the implementation of the risk prevention and management policy within the activity he oversees.

It is necessary to initiate a risk prevention strategy, which involves detecting hazards, assessing, controlling, and managing risks to prevent incidents. In the professional environment, employees face various risks without truly understanding their long-term impact on human health (MP). It is essential to recognize the risky situations that employes may face in order to manage the related dangers and ensure the safety of people, property, and the environment.

I.2. Hygiene and safety

I.2.1. Definition

It is a field of technical expertise that controls aspects related to occupational risks within the company in order to lead to an integrated management system. Given the links between the different areas, hygiene and safety can be involved in quality management, safety management, or environmental management within the company. In this capacity, the hygiene and safety officer is responsible for ensuring the safety of the staff, their training in prevention, compliance with standards, and the reliability of the company's facilities.

I.2.2. Different areas of the sector

- Preservation of human health while ensuring medical monitoring and also reducing potential nuisances and risks of accidents related to the workstation.
- Ensure good preventive maintenance and rational use of equipment (fire risks, electrical

risks, etc.). Ensure that the safety devices of the production equipment are always in place and functional.

- Preservation of the environment while paying attention to waste (treatment, storage, sorting). and ensure that our activity does not have dangerous impacts on our environment.
- Workplace accidents also have a cost, reducing them means reducing our production cost.

I.2.3. The hygiene and safety sectors

- An activity frequently practiced within communities (administrative buildings, nurseries, shelters, educational institutions, prisons,...) ;
- In catering (central or school kitchens, hotels restaurants, university or company restaurants, food processing industries,...) ;
- In healthcare (hospitals, medical retirement homes, care centers, laboratories,...) ;
- In industry (electronics, mechanics, automotive,...) and other establishments (banks, sports facilities,...).

I.2.4. Role of the hygiene and safety specialist

- The hygiene and safety officer's mission is to reduce workplace risks: accidents, occupational diseases, fires, pollution. The hygiene and safety officer's mission is to reduce workplace risks: accidents, occupational diseases, fires, pollution. This security specialist has a preventive role. He checks the proper functioning of alarms, access cards, fire doors, organizing "fire drills" for the staff is his responsibility, as is the training of agents in evacuation and intervention techniques.
- The security officer also has a supervisory role, ensuring compliance with the standards and guidelines they have defined.
- From the ban on smoking in offices to the mandatory wearing of helmets on construction sites, he scrutinizes everything.
- Faced with a more specific risk (industrial pollution, for example), the company calls on a hygiene, safety, and environmental engineer belonging to a consulting firm.
- Specialist in a field (chemistry, biology, electricity, computer science), they identify the risks of malfunction and provide solutions.

- He ensures the safety of personnel and facilities (boiler rooms, electrical installations, ventilation, aeration, and medical gas installations) and contributes to the improvement of working conditions.

I.3. Definitions and concepts related to aspects: health, safety, and environment

I.3.1. Hygiene

It is the set of collective or individual means, as well as the principles and methods, aimed at maintaining or improving health. This is the case for preventive actions to be applied in the context of the fight against infectious diseases. In a professional context, we could mention, for example: implementation of cleaning contracts; raising hygiene and health standards; prohibiting eating meals in the workplace; ventilation of professional spaces.

The objectives of hygiene are:

a. Operational objective: ensure the health of people at work.

b. Strategic objectives:

- Identify the aggressions of the industrial environment toward the individual.
- Detect (discover) new and emerging risks.
- Evaluate the resulting risks for the individual.
- Recommend protective actions.
- Verify the effectiveness of the actions taken by possibly correcting them.
- Monitor the biological and physical impact of the applied measures.

c. Tactical objectives:

- Inform about the nature, importance, and effects of the risks.
-Make known the means to control them.
- Train the personal involvement of each person at work.

I.3.2. Security

The term "company" can refer to a variety of situations, ranging from a simple individual business to colossal corporations that employ a large number of workers and interact with a multitude of individuals. The resources, team, and structures vary from one company to another, but when it comes to security, the principles to follow remain the same.

How to approach security in the same way as any other business activity? We can summarize security as follows:

- The condition of what inspires confidence, the absence of incidents or unacceptable danger.
- This refers to the situation where someone or something is not exposed: without danger; without risk of physical assault, accident, or theft.
- It is the set of legislative and administrative actions aimed at protecting individuals and families against specific risks, known as social risks.
- These are all the essential prevention and assistance actions, in any situation, for the protection of populations.
- Security should not be considered solely by an expert, but by everyone.
- Effective security is incorporated into the operations, processes, as well as all the activities of the company.
- High-performance security is incorporated into operations, processes, as well as all company activities. Every accident is preventable.
- Each individual is responsible for ensuring their own safety as well as the safety of those around them.
- Each individual is responsible for their own safety as well as that of those around them. Safety primarily relies on the individual behavior of everyone, including that of the managers, at all levels.

The security approach involves ten fundamental points, which are:

1) The commitment of leaders-security policy:

-Clearly express what is expected of the staff;

-Encourage initiatives, good results, good behaviors;

-Discourage bad behaviors; -Inquire with these collaborators about their safety results;

-Conduct safety visits;

-Take an interest in safety results and the actions taken for their improvement;

-Define a safety policy: its long-term objectives, its reasons, and the means to implement it;

-Respect this policy and monitor its application and results;

-Have a safety strategy.

2) Clearly established, known, and applied rules: rules and procedures help achieve results and proper execution. It is surprising how many companies neglect to establish clear operating rules; yet, it is essential to establish what each person is expected to accomplish in their role. It is also crucial that each manager defines what is meant by "best practices" in a work environment, and organizes them into four categories: essential, applicable, known, and implemented.

Indeed, it is essential to have a reference, even tho it is not exhaustive. It must be constantly updated and adjusted when deemed necessary. Everyone must adhere to this framework, including visitors and the hierarchy.

3) Objectives and action plans: the objective must be: clear, understandable by all; realistic; accompanied by the means to achieve it.

Once the manager has outlined their security policy, it is then necessary for them to consistently implement it. It is necessary to address the root causes of problems and accidents, which involves knowing and examining them. We will therefore have a mechanism to identify and examine the problems: feedback. The goal being to anticipate these problems, we will have an action plan to assess the risks associated with all the company's operations.

4) The training: safety training should, at least partially, be included in professional training, namely:

- Safety instructions and rules, arising from both legal obligations and a particular environment (site, construction site, etc.);
- First aid;
- Gestures and attitudes for those who have to perform manipulations; specific manipulations (fire extinguishers, etc.);
- Training in methods, approaches, and tools (accident analysis, risk analysis, safety visit and meeting, not to mention the training of CHSCT members.

5) Exploitation of experience: it is necessary to address two facets of this issue: the study of accidents and the lessons learned from these incidents. These two elements are indicative of a "feedback." Regarding the lessons to be learned from experience, the analysis of locally occurring accidents is a first step, nevertheless, it is also imperative to pay attention to events

that have occurred in other places (such as other sites, workshops, etc.).

6) Staff motivation: facilitate dialog, encouragement, promotion...

7) Communication: in a company, which is a hierarchically structured environment, communication must be organized to function. Otherwise, the usual barriers (hierarchy or other organizational elements such as varied activities), behavioral (rivalries), and geographical (distant sites) will serve as a filter.

8) A specific organization: it is thru a simple organization that the managers will be able to manage the entire security system, and first and foremost thru a governing body.

9) Control, recycling: in all management systems, the concept of control is essential. The verification must be done in real time to ensure before, during, and after a specific task that there is no deviation from the objective.

10) Perseverance: improving behaviors at all levels of the company plays an essential role in the pursuit of optimal safety. When committing to a security approach, it is essential to position it for the long term. Any interruption in the monitoring of security management leads to the failure of the established policy.

I.3.3. Environment

Importance of the environment for the company (figure 1):

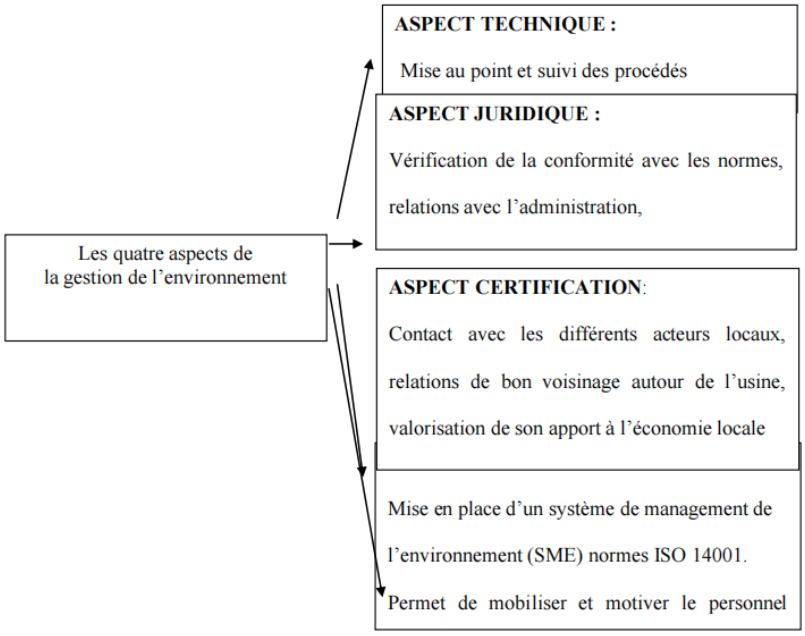


Figure 1: Different aspects of environmental management

I.3.3.1. Technical aspect

- Develop safer and more environmentally friendly technologies:

  -Depollution system.

  -Anti-pollution system, clean technology: reorganization of production workshops; modification of manufacturing processes; use of clean processes where the nature of production processes is radically changed.

- Minimize the waste and emissions generated and treat them without risk to the environment.
- Reduce the environmental impact of production sites:

  - Acting on pollutant discharges also means understanding the dangers they can cause;

  - Residual pollution must be treated with the most appropriate technologies and their impacts must be evaluated after purification.

I.3.3.2. Legal aspect

- Be in compliance with regulations (it's an obligation);
- Control costs:

  - Aqueous discharges: withdrawal fee + pollution fee + treatment costs;

  - Atmospheric discharges: parafiscal tax + treatment costs;

  - Waste: ADEME tax + treatment costs;

  - Polluted soils: study and remediation costs.

I.3.3.3. Aspect certification

- Meet the expectations of the "neighborhood" and other interested parties:

  - Implement an Environmental Management System (ISO 14001);

  - Gain the trust of residents, clients, insurers, various associations, the administration, ...;

  - Demonstrate a good level of environmental performance (low impacts, controlled risks).

- Be mindful of the impact of products and production methods on the environment: the survival of the environment = the survival of the company.

I.3.3.4. Image/ communication

- Give a better brand image of the company to the outside world.
- Cooperate and communicate with customers, suppliers, and public authorities to improve products and the production tool while minimizing their impact on health and the environment: information brochures, open house, customer feedback processing.
- For the company, the environment is a source of new opportunities: risk reduction, cost reduction, consolidation of market positions, improvement of working conditions, staff motivation, public trust, better brand image with the public and local residents.

I.4. Hygiene-Safety-Environment (HSE) Structure

I.4.1. Sustainable development approach - HSE approach

- Protection of people and populations: ensuring the health of employes at their workplace.
- Protection of assets/economic efficiency: profitability, reputation, brand image, security.
- Respect for third parties and our environment: chronic and accidental discharges/waste; products purchased/sold (complete product life cycle).

-Respect for laws and regulations imposed by public authorities: safety/hygiene-health/environmental protection result from the proper articulation of preventive elements (regulations, implemented actions): application and control modality; permanent research based on knowledge of texts and experience; staff training.

I.4.2. Usual functions of an HSE structure

I.4.2.1. Role of the HSE structure

Protect the individual and their environment from humans thru: prevention, elimination, risk reduction.

I.4.2.2. Objectives of the HSE service

The HSE service has several objectives (figure 2).

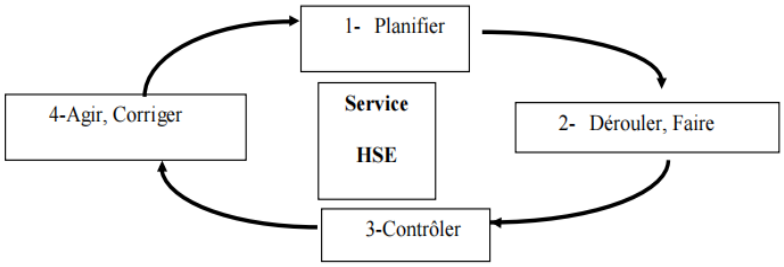


Figure 2: Continuous improvement cycle (Deming wheel)

1. Plan:

Contribute to the establishment of the site's HSE policy in terms of objectives and resources.

2. Implement/Do:

- Write and keep HSE instructions/specific plans up to date;
- Know/centralize and disseminate all useful documentation (recommendations, regulatory obligations, …);
- Ensure HSE prevention training for staff;
- Lead HSE communication efforts.

3. Control the effectiveness of the policy:

- Verify compliance with instructions;
- Conduct daily HSE rounds on site;
- Conduct HSE audits on site, particularly at construction sites;
- Analyze HSE malfunctions;
- Participate in keeping statistics up to date and publishing the annual report of the Committee for Hygiene, Safety, and Working Conditions (CHSCT).

4. Correct:

- Learn from past mistakes to prevent them from recurring;
- Initiate the necessary corrective actions following any HSE malfunction;
- Lead/coordinate the fight against disasters.

I.4.2.3. Missions

The different objectives of an HSE service can be translated, in another way, into missions:

a) Research: analyzes accidents and working conditions; develops "technical" statistics; participates in prevention programs; manages technical and regulatory documentation and ensures regulatory monitoring.

b) Operational: safety campaigns (reception, training, conferences); firefighting; verification and controls of installations, materials, and products; maintenance of equipment and protective measures; first aid and evacuation of the injured; compliance with legal organizations.

c) Functional or advisory: on the design and modification of facilities; participates in the development of safety instructions and procedures; participates in the development of prevention plans.

d) Liaison with: the occupational health service; the departments or directorates of the establishment; external prevention organizations; staff representatives on the CHSCT (Committee for Hygiene, Safety, and Working Conditions); state organizations.

I.4.2.4. Example of HSE service actions

a. Preventive actions

Procedures:

- Personal regulations (safety manual);
- HSE guidelines;
- Regulations and selection of external companies;
- Procedure/safety committee/work permit.

Motivation awareness:

- Information/training;
- Campaign: contest, posters, film, intranet;
- Exercises;
- Committee/security.

Study-implementation of works to reduce risks:

- Suggestions/advice;
- Hazard studies;
- impact studies;
- Periodic visit;
- Audit.

b. Curative actions

Fight against fire and pollution

- Action plans: 1st emergency/2nd emergency; civil protection; colleagues and third-party organizations.

- Circuit equipment: fire water; emulsifiers; vehicles; fixed installations; detectors, pollution control equipment.

Protection of facilities

- Plans: emergency; POI (internal operational plan); PPI (special intervention plan); bomb alert.
- Means: security agents; first aid team; firefighters, …

Emergency plans are practical documents intended to list all the measures to be taken in case of an incident, pollution, or contamination, with the aim of:

- Organizing the deployment of emergency services efficiently and quickly;
- Organizing the priority actions to be taken;
- Facilitating interventions;
- Informing the competent authorities.

This is with the aim of ensuring optimal responsiveness to minimize physical and material damage. The development of a crisis management plan, before a crisis occurs, leads to identifying the types of incidents that are likely to occur, their impacts, and the resources to mobilize. The main objective being: to manage the crisis as efficiently and quickly as possible, which requires perfect coordination and a strong capacity for reaction. POI and PPI plans: both include the following elements:

- The indication of the risks for which the plan is established;
- The analysis of the different possible accident scenarios and their most penalizing consequences;
- The organizational measures;
- The intervention methods;
- The means and equipment necessary for the protection of personnel, populations, and the environment;
- The alert and information circuits for the competent authorities and all stakeholders (administrations, elected officials, media, associations, …).

The Internal Operation Plan (POI)

It is for managing a crisis or internal pollution within the company without the risk of spreading outside the site and at the initiative of the operator. The POI is triggered and implemented by the Director of Internal Operations (DOI: Company Director or their representative).

The Special Intervention Plan (PPI)

It is for managing a crisis or internal pollution within the company with propagation outside its premises and at the initiative of state services, particularly the city (in Algeria). The PPI is triggered and implemented by the governor or their representative.

In Algeria, in accordance with Executive Decree No. 09-335 of October 20, 2009, which determines the modalities for the design and implementation of internal intervention plans by operators of industrial facilities, as well as the interministerial decree of 17 Dhou El Kaada 1431, corresponding to October 25, 2010, establishing the model for the creation of the internal intervention plan. An internal intervention plan (PII) is designed in accordance with the model attached to the interministerial decree with the aim of:

- Serve as a basic and support document for managing an incident;
- Identify (all human and material resources to be implemented in case of an incident and set the conditions for their implementation;
- Constitute a document that can serve as a tool for conducting exercises, training, and preparations for emergencies;
- Constitute an official document that meets regulatory requirements;
- Provide written data that will facilitate the involvement of support entities during the emergency;
- Provide a basis for the continuous improvement of emergency management performance on the site.

In accordance with the decree, the approved internal intervention plan (PII) must be distributed to the following recipients: the governor; the president of the APC of the location; the director in charge of industry of the city; the director of civil protection of the city; the director of the environment of the city; the director of the concerned sector of the city; the

security officer of the establishment; the head of the establishment. A copy must be made available to the staff.

The establishment (the unit to be operated) must call upon a qualified third party (study office) to conduct an impact and hazard study (IHS), following which an internal intervention plan is developed for implementation at the establishment level.

I.4.3. Role of the prevention engineer HSE

I.4.3.1. Position

It is to ensure and enforce the necessary prevention to eliminate the risk of accidents of any kind and to monitor and report any situation or process contrary to the internal regulations and legal provisions on safety and occupational health/hygiene, the environment. Also to inform, instruct, train the fire and environmental risk response teams to develop the staff's knowledge based on the equipment available on site.

I.4.3.2. Responsibilities

- Organize and plan the service's work among its various members;
- Coordinate the work and personnel management;
- Monitor the work performed;
- Ensure technological and regulatory monitoring in the HSE field;
- Receive representatives or suppliers of protective equipment or equipment for combating HSE risks or incidents;
- Keep intervention teams perfectly trained and materials in excellent condition;
- Control and monitor staff training in the HSE field;
- Ensure, by delegation from Management, relations with the supervisory administration.

I.4.4. Elements of excellence in the HSE management system

I.4.4.1. Leadership

- Strong leadership commitment demonstrated;
- Ambitious goals and plans;
- Security policy and principles;
- High performance standards.

I.4.4.2. Organization

- Support for HSE teams;
- Hierarchical HSE responsibility;
- Integrated HSE organization;
- Progressive motivation.

I.4.4.3. Operations

- Effective communication;
- Continuous safety training;
- Investigations/reports of injuries and incidents;
- Regular audits and re-evaluations.

I.4.5. HSE system improvement process

I.4.5.1. Commitment and responsibility

- HSE policy;
- Objectives and improvement programs;
- Organization and responsibility;
- Regulatory compliance.

I.4.5.2. Risk management

- Process for identifying hazards and assessing HSE risks;
- Integrated process safety;
- Management of changes;
- Management of new projects;
- Operational mastery.

I.4.5.3. Management of occupational health and safety

- Ergonomics and working conditions;
- Industrial hygiene;
- Risk management related to workstations.
- Management and monitoring of occupational diseases, work-related conditions, and contagious diseases;
- Emergency care and first aid;
- Management and medical monitoring of accidents;
- Work abilities.

I.4.5.4. Environmental Management

Management: of liquid discharges, atmospheric emissions, waste, nuisances (noise and

odors at the site boundary), chemical and hazardous products, natural resources (water and energy). Management and rehabilitation of contaminated sites and soils.

I.4.5.5. Contractor Management

- Partnership;
- Management of suppliers (products and equipment) and subcontractors (services and on-site intervention).

I.4.5.6. Communication and documentation

- Communication: internal, external;
- Documentation.

I.4.5.7. Training and qualification

Includes training programs and qualification requirements.

I.4.5.8. Management of accidents and incidents

- Reporting of accidents, incidents, and near-accidents;
- Investigation process;
- Recording, statistics, and feedback.

I.4.5.9. Emergency and crisis management

- Emergency plans;
- Crisis management.

I.4.5.10. Audit and review

- Audit;
- System audit;
- Inspection and control;
- Review of HSE and programs.

I.5. Regulations related to hygiene and safety

I.5.1. Health: Law No. 88-07 of January 26, 1988, concerning hygiene, safety, and occupational medicine:

➢ Legal anchoring of occupational health

• Article 54

- All citizens have the right to health protection.

- The state ensures the prevention and control of epidemic and endemic diseases.

• Article 55

- The right to protection, safety, and hygiene at work is guarantyd by law.

- The right to rest is guaranteed. The right to rest is guaranteed.

➢ Excerpts from Algerian labor legislation

• Article 5 - Law 90-11. The fundamental rights necessary for workers are as follows:

- Social security and retirement;

- Hygiene, safety, and occupational medicine;

- Rest.

• Article 6 - Law 90-11. Workers also have the right to respect for their physical and moral integrity and their dignity.

•Article 2-Law 88-07. The employer organization is required to ensure the hygiene and safety of workers.

•Article 13-Law 88-07. Occupational medicine is an obligation of the employer. It is his responsibility.

•Article 20-Law 88-07. The implementation of all activities related to hygiene, safety, and occupational medicine is financed by the employer organization.

I.5.1.1. The objectives of Law No. 88-07 of January 26, 1988, concerning hygiene, safety, and occupational medicine

• Define the ways and means to ensure the best conditions for workers in terms of hygiene and workplace safety;

• Define the responsible persons and employer organizations in charge of implementing the prescribed measures.

I.5.1.2. General rules regarding hygiene and occupational safety

• Employer's obligation to ensure hygiene and safety for workers;

• Guaranty the cleanliness of work premises;

• Ensure comfort in terms of ventilation, lighting, heating,…

• Introduction of the concept of individual protection;

• Integration of worker safety in the choice of techniques and technologies and in work organization.

I.5.1.3. General rules in occupational medicine

• Protection of workers' health;

• Ensuring the highest level of physical and mental well-being;

• Preventing and protecting workers from risks that could lead to accidents or occupational diseases and any damage caused to their health;

• Occupational medicine is an obligation of the organization and at its expense, it is practiced on the very premises of the workplace.

I.5.1.4. General rules regarding training and information

• Instruction, information, and training related to occupational risks are an obligation for the employer;

• New recruits or those called upon to change positions, methods, or means must be informed of the risks they may be exposed to at their workstation;

• Depending on the frequency and severity of the observed risks, specific training actions are organized for the concerned workers for prevention purposes.

I.5.1.5. Organization of prevention

• Establishment of hygiene and safety committees;

• Obligation for any organization employing more than 09 people to appoint a permanent hygiene and safety officer;

• Establishment of a national council for hygiene, safety, and occupational medicine that participates in defining the national policy for the prevention of occupational risks.

I.5.1.6. Control

• The control of legislation is delegated to the labor inspection;

• When violations are observed, the labor inspector requires the head of the employing organization to comply with legal and regulatory requirements;

• The CHS or the security service can notify the labor inspection in case of blatant negligence or a risk for which measures have not been taken;

• The employing organization must keep special records allowing the labor inspector to exercise their control.

I.5.2. Environment: Law No. 03-10 of 19 Joumada El Oula 1424 corresponding to July 19, 2003, relating to environmental protection within the framework of sustainable development.

I.5.2.1. Objectives of the law

- Define the rules for environmental protection within the framework of sustainable development;
- Set the fundamental principles and rules for environmental management;
- Promote sustainable national development;
- By improving living conditions and working to ensure a healthy living environment;
- Prevent any form of pollution or nuisance;
- Caused to the environment by ensuring the preservation of its components;
- Restore damaged environments;
- Promote the ecologically rational use of available natural resources, as well as the use of cleaner technologies;
- Strengthen information, awareness, and public participation and various stakeholders in environmental protection measures.

I.5.2.2. The principles of the law

The principle of: preservation of biological diversity, non-degradation of natural resources, substitution, integration, preventive action and correction, with priority at the source, of environmental damage, precaution, polluter pays, information, and participation.

I.5.2.3. Law establishes protection requirements

- Of biological diversity;
- Of air and the atmosphere;
- Of water and aquatic environments;
- Of land and the subsoil;
- Of desert environments;
- And of the living environment.

I.5.2.4. Law establishes the requirements for protection against nuisances

- Related to chemical substances;
- Acoustic or related to noise

Chapter II: Work Accidents

II.1. Introduction

When addressing the issue of workplace safety, it is impossible to avoid topics related to safety, industrial hygiene, the environment, and even quality. Indeed, any initiative aimed at permanently reducing the risk of accidents or "near misses" demonstrates that the concept of an accident can be extended to that of a breakdown, incident, stoppage, loss, in short, anything that represents a malfunction: hence the obvious link with quality.

Acting to strengthen security will therefore lead to an improvement in quality. Nowadays, companies associate hygiene, safety, environment, and quality by entrusting all these responsibilities to a single prevention and quality director.

Prevention aims to reduce the possibility of an "undesirable" incident or breakdown, such as an injury or even the creation of a toxic cloud. Maintenance can contribute to this, as a preventive measure for machinery.

II.2. Some definitions

II.2.1. Danger

Refers to a material condition that presents a risk of impact on the physical integrity of individuals, damage to property or the environment, or a combination of these harms. Danger constitutes a possible threat of harm, while risk corresponds to an estimate of exposure to that harm. The idea of danger and exposure to it is essential; if this is not clearly defined, we fall back into classic errors, analytical mistakes, and inappropriate decisions.

II.2.2. The risk

Risk, a tricky word where both danger and consequence are confused, is the combination of the probability of a malfunction occurring and its potential severity. Risk measures the level of danger. Risk represents the possibility that a specific event will occur within a specific time frame or under defined conditions.

We generally characterize a source of risk by the presence of one or more potential risks, that is, a situation bringing together all the elements likely to cause a potential accident or generate an undesirable incident compromising the safety of individuals, the security of equipment, and the environment (figure 3):

-**Dangerous products:** flammable, explosive, toxic, polluting;

-**Dangerous chemical reactions:** incompatibility, corrosion, thermal runaway, release of toxic products;

-**Operating conditions:** pressure, temperature, electricity, radiation, energy, noise, heat/cold.

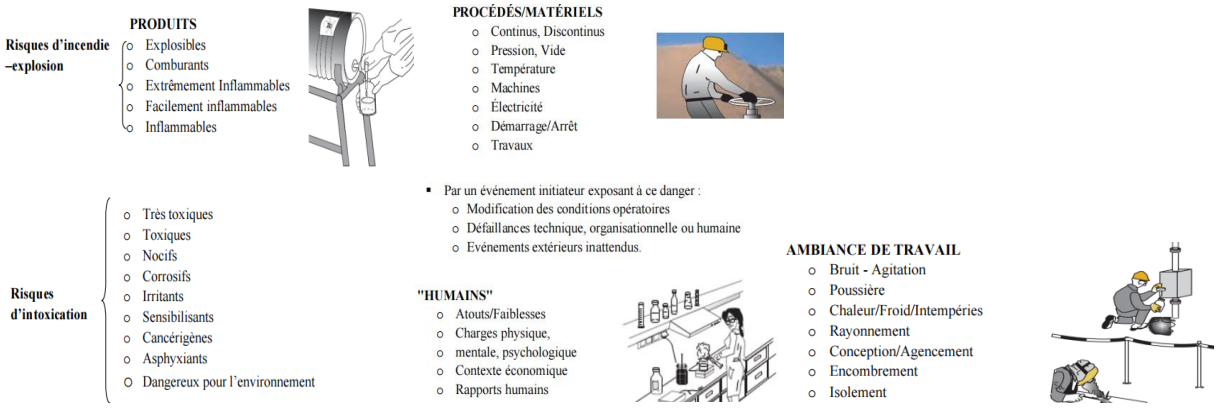


Figure 3: The presence of a risk.

II.2.2.1. Risk assessment

Everyone has their own perception of risk, whether they are a manager, employee, student...well, our personal behavior often follows irrational motivations (anger, pride, stress, confidence...) that can make us minimize or even deny the real danger of a situation.

II.2.2.1.1. Notion of exposure

The risk results from exposure to a danger: **Risk = Danger x Exposure**.

The risk of an accident (human damage) occurring is low or non-existent because no workers are present at the site of danger (probability of the plant falling), this situation represents the notion of **"no exposure"** therefore no risk (figure 4.a).

The risk of an accident (human damage) occurring is very high due to the high probability of workers being present at the site of danger (probability of the plant falling). This situation represents the concept of **"Dangerous situation and notion of exposure"** (figure 4.b).

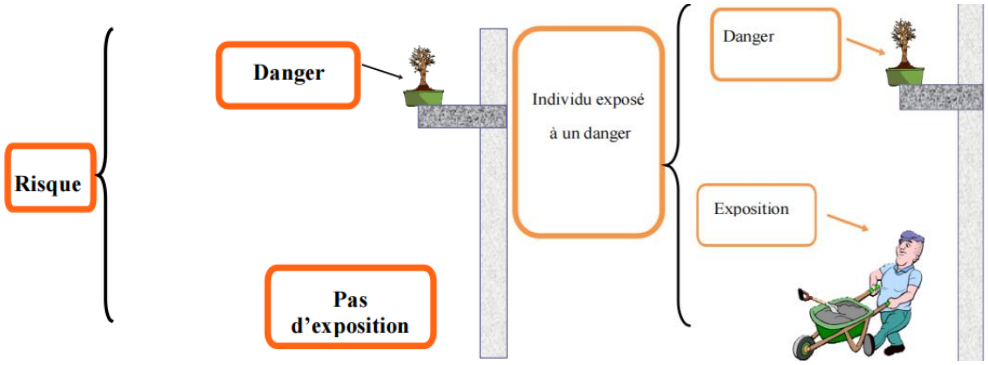


Figure 4: Diagram representing situation a: "no risk" and b: "dangerous situation".

II.2.2.1.2. Risk-taking

An individual's risk-taking is not based on the actual risk, but on their perception of that risk. Or if we don't have a method to evaluate the risk, we are very likely to be mistaken.

II.2.2.1.3. Risk-based approach

The level of risk has long been defined by a two-dimensional quantity associated with a specific phase of the activity of the studied installation (figure 5) and characterizing an undesirable event by:

-The level of severity: assessment of potential harm to individuals (lethality, irreversible injuries) and damage to equipment (internal and external assets of the company).

-The level of probability: estimation of its probability of occurrence.

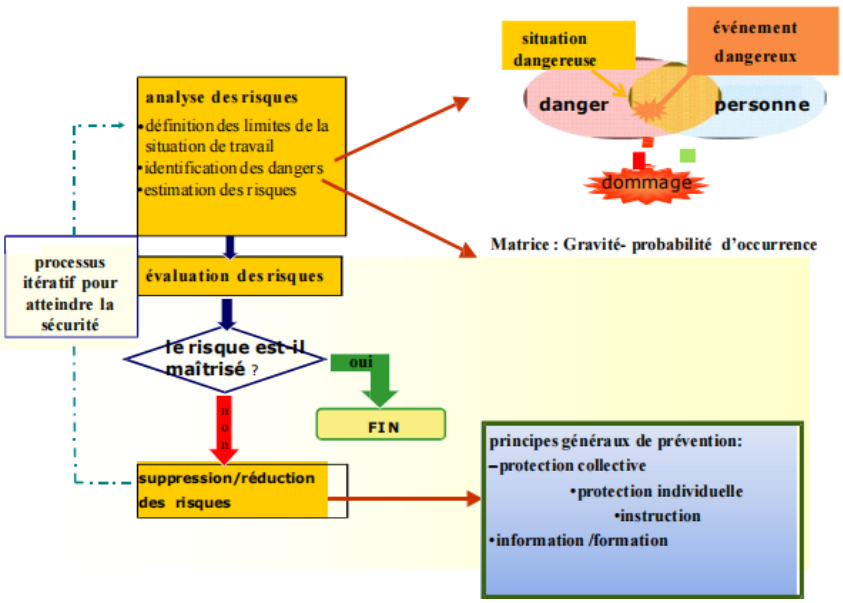
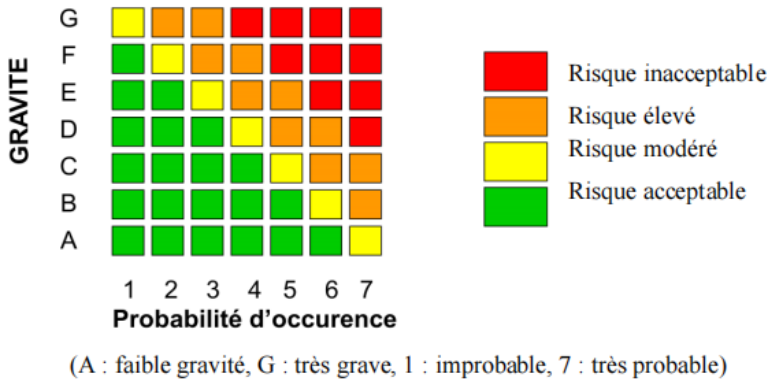


Figure 5: The risk-based approach process.

II.2.2.1.4. Risk assessment matrix: Severity – Probability of occurrence

Several levels of severity can be defined, they evolve: depending on the countries, the societies; or with time and the evolution of technologies. Thus, the level of severity can vary from one risk analysis to another, from one industry to another (figure 6).



(A : faible gravité, G : très grave, 1 : improbable, 7 : très probable)

Figure 6: Risk Assessment Matrix

Industrialists use this risk level assessment matrix to conduct preventive risk analysis studies using the so-called "probabilistic" method. It is also adjusted and implemented:

-For the assessment of incidents and accidents: the risk level situation allows for the definition of:

- The levels at which information regarding the accident will be disseminated (concerned sector of the plant, the plant, the group, the profession) to contribute to the sharing of experience;
- The level of decisions validating the analysis and action plans to prevent the recurrence of the accident (concerned sector, site management, group management).

- To define a maintenance strategy, based on the risks associated with equipment failure.

The degree of risk determines the urgency of maintenance actions and the management of spare parts inventories.

II.2.2.2. Different types of risks

Any human activity involves risk. In the event of a hazardous situation, the risk of an undesirable event (ENS) occurring can lead to harm (whether it be an accident or an illness). The idea of risk also implies that of harm. A nuisance is anything that causes harm, that attacks, that disturbs. It is a product or phenomenon that could harm humans as well as nature in general (flora and fauna), thereby disrupting their functioning and balance.

Noise is a form of sound pollution that can lead to deafness. Continuous exposure to high noise levels can lead to hearing loss in an individual. Moreover, deafness is among the most common occupational ailments. Electricity is the indispensable source of energy for our modern lifestyle, electricity is ubiquitous in our current technologies. This form of energy risks becoming a source of harm, as it presents a danger of electrification or electrocution.

Every human action generates nuisances that manifest as risks. It can be argued that every form of life generates nuisances of various levels, capable of influencing the environment. According to the nature and specificities of the nuisances, it is necessary to make a distinction:

II.2.2.2.1. Industrial risks

Industrial risks, particularly those leading to major accidents, can manifest as serious incidents likely to cause a large number of casualties, significant material damage, and significant environmental pollution. Industrial accidents are characterized by:

- Fires possibly preceded or followed by explosions;
- Explosions possibly preceded or followed by fires;

- The formation and release into the environment of harmful or toxic substances (vapors, fumes...).

Most often, these accidents are said to be major because they are followed by serious and numerous consequences: victims among employes and the population; destruction of buildings due to fires and explosions; more or less severe poisonings due to the emission of dangerous substances; pollution of nature by the toxic pollutants emitted.

II.2.2.2.2. Occupational risks

Work accidents and occupational diseases are manifestations of professional risks. These risks are of small scale and their effects are limited to the premises or workspaces, workshops, laboratories, offices, as well as the employes and workers involved. Work accidents and occupational diseases are caused by occupational hazards.

It is important to distinguish among the following occupational diseases:

- Occupational pathologies are health impairments resulting from the absorption of small quantities over a more or less long period of dangerous substances to which the victim was exposed during the performance of their duties.
- Among occupational diseases, examples include: occupational deafness (exposure to high noise levels); anemia, leukemias, contact caused by ionizing radiation (X-rays, gamma rays...); occupational lead poisoning,...

II.2.2.2.3. The risks of everyday life

The dangers of daily life, such as domestic accidents, incidents related to leisure or DIY activities, etc., constitute a very broad, complex, and arduous field of study to grasp.

The main distinction between these three types of risks lies in the extent of the damage caused during accidents. Occupational risks only affect a limited number of people, namely employes working near potential hazards. Risks associated with daily life generally affect an individual. On the other hand, major industrial risks can lead to serious accidents with numerous victims, both among on-site employes and the surrounding population, often resulting in significant material damage.

The main distinction between these three types of risks lies in the extent of the damage caused during accidents. Occupational risks only affect a limited number of people, namely employes working near potential hazards. Risks associated with daily life generally affect an individual. On the other hand, major industrial risks can lead to serious accidents with numerous victims, both among on-site employes and the surrounding population, often resulting in significant material damage.

II.2.3. Damages or consequences

Impact of an event on the assets, individuals, and operations of a system. The damages can be quantified in terms of people, money, economy, society, or environment (figure 7).

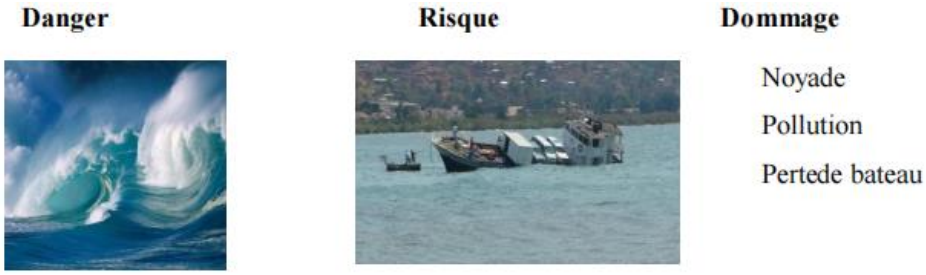


Figure 7: Diagram representing: Danger – Risk – Damage

II.3. Work accidents

II.3.1. Definitions

II.3.1.1. Work accident

We can define a work accident as a bodily injury, temporary or permanent, caused by an external, sudden, and rapid event. We distinguish based on the severity of the injuries:

- Accidents without time off, minor, often without follow-up and that can be treated on-site.
- Accidents with time off (from a few days to a few months) with injuries requiring special care.
- Accidents with permanent disability (PD) corresponding to definitive injuries and sequelae, likely to reduce work capacity (partial or total disability).
- Fatal accidents with immediate death or coma followed by death.

The work accident within a company or professional activity is defined by several parameters, the most important of which are:

Frequency Index (FI)=(Number of accidents with time off x 1000)/Number of employees

Severity rate = (Number of days off x 1000) / Number of hours worked

Some examples of work accidents originating from well-known risks:

- Hands caught and crushed by the moving parts of a machine tool;
- Falls on the stairs; - Breathing in toxic gasses and vapors in poorly or unventilated areas.

II.3.1.2. Near accident

-A sudden and unexpected event, which could have, under slightly different conditions, caused an accident.

- Dangerous circumstances: no injuries to staff, but property damage warnings of future events.

II.3.1.3. Incident

An undesirable incident that occurred during work and did not result in physical injuries. The diagram below shows the distinction between: Accident–Near miss–Incident (figure 8).

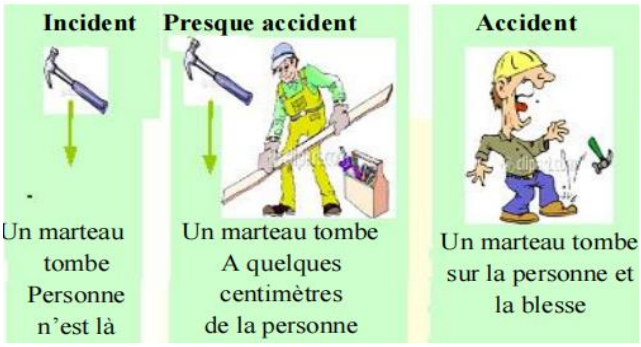


Figure 8: Diagrams representing the situations of incident, accident, and near miss.

II.3.2. Scale of severity

Low frequency: we are often inclined to forget that these events are rare. Significant severity: numerous, victims, loss of image, damage to property and the environment. Type of accident classification (figure 9):

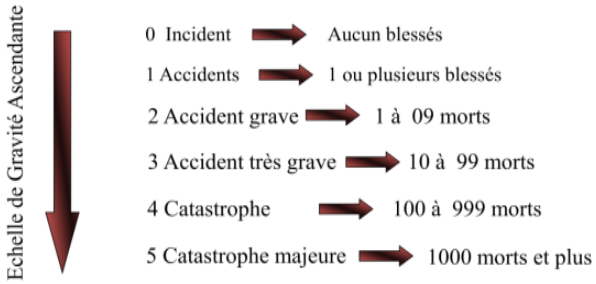


Figure 9: Classification of accidents

II.3.3. Analysis and investigation of accidents

II.3.3.1. Obligations

-Accident report: any employee who is the victim of a work-related accident must immediately, or as soon as possible, notify their immediate supervisor.

-First aid: when the victim of an accident requires first aid, a certified first help present in the company must be able to provide it.

II.3.3.2. Actions to take in case of an accident

The company must structure itself to be able to intervene in case of an accident. You must report any incident to the person in charge of department. He will therefore take care of:

- Triggering emergency measures if necessary; making the premises and equipment safe (e.g., stopping the machine, protecting the affected area, keeping onlookers away);
- Securing the individuals involved;
- Identifying sources of evidence and protecting them against any modification or movement;
- Initiating the investigation and analysis of the accident.

II.3.3.3. Accident, first aid, and emergency register

The company must record all accidents that occur at work, as well as all information related to the first aid provided. It is possible to record this information in the accident, first aid, and emergency register.

For each incident resulting in an injury (including minor injuries), the on-duty first aider or the direct supervisor of the individual involved must record the details of the incident in the specific register for this purpose.

Beside complying with a legal requirement, the register of accidents, first aid, and emergency care can serve as a crucial prevention tool for the health and safety committee within the company. The committee should review this at each meeting. After gathering the details about the accident, if corrective actions are feasible, it is the responsibility of the injured person's direct supervisor to implement them as quickly as possible.

II.3.3.4. Accident investigation and analysis

- Which accidents to investigate? Ideally, all accidents resulting in injuries or damages should be investigated. Accidents that could have caused injuries or damages should also be investigated. Each case being specific, it is up to the person in charge to evaluate the situation to determine whether or not it is relevant to conduct an investigation.

- Who conducts the investigation? Who conducts the investigation? The immediate supervisor conducts the investigation in the company of a worker who is a member of the health and safety committee. Ideally, the person who was the victim of the accident also participates in the investigation.

- When to investigate? The investigation must be carried out as soon as possible, preferably immediately after the accident.

- Where and how to investigate? At the scene of the event, using forms provided for this purpose.

II.3.3.4.1. Accident analysis using the cause tree method

We start from the premise that not every accident is fatal. When an accident occurs, it has one or more origins, the analysis aims to decipher these origins. We have multiple techniques to identify the various origins that led to the accident or malfunction.

The cause tree method created in the 1970s is a practical method for analyzing accidents or incidents, offering a logical and rational approach to data collection during the post-accident investigation. Based on facts, it allows for the connection of causes to the effect (the workplace accident). It allows for the exploitation of the collected information in order to design prevention action plans. It belongs to the family of problem-solving tools. The work

done in a group helps to enrich and deepen the analysis as well as to seek security solutions better suited to the activity.

II.3.3.4.1.1. The basic rules

A cause tree aims to understand an accident, whether it is a work accident or not, the approach is not to judge, nor to find a culprit, but to identify the causes of the event. Once the causes have been identified, it is necessary to identify the factors that generated the event, whether they are technical, organizational, or human in nature:

- Conduct the analysis in a group: victim, witnesses, hierarchy, security service, etc.;
- Intervene as early as possible at the scene of the accident;
- Avoid looking for culprits, interpreting, or finding ready-made solutions.

II.3.3.4.1.2. Creation and analysis of a cause tree

This is the phase of formulating hypotheses regarding the causes of the accident. This phase follows the initial collection of data and facts (related to the consequences, the timeline, and the initial information about the circumstances of the accident). Generally, this hypothesis formulation phase serves to structure:

- The known facts and results;
- The unknown information that would require future data collection and analysis.

This phase essentially aims to clarify: what happened, under what circumstances, why. There are several principles for creating a cause tree:

a) Key principles

Accident analysis by cause tree is based on the following key principles:

- Identification of direct causes;
- Deductive method starting from a final event (accident, near accident);
- Decomposition of facts into elementary, independent events;
- Evaluation of logical connections between events and combination of events;
- Provision of a graphical representation;
- Preparation of the most plausible scenario formulation by providing necessary and sufficient causes to confirm or rule out.

b) General principles

It is a deductive method that, starting from a feared event, a consequence, or an accident, aims to determine the logical sequences or combinations of events that could ultimately lead to the accident.

It focuses on determining the direct causes (equipment failures, human actions) as opposed to the root causes. It allows for tracing back from causes to causes until reaching the basic events likely to be at the origin of the dreaded event (near accident) or the accident.

Whatever the nature of the identified basic elements, the cause tree analysis is based on the following principles:

- These events are independent;
- They will not be broken down into simpler elements due to lack of information, interest, or because it is impossible;

The cause tree analysis of an accident or near-accident (feared event) can be broken down into three successive stages:

- Definition of the accident or feared event being studied;
- Development of the cause tree;
- Evaluation of the plausibility of the causes (removal or retention of branches) in order to define the (and by default the) most probable scenario(s).

It is necessary to add to these steps a preliminary step of system knowledge and prior risk awareness.

c) Starting the cause tree from the final or dreaded event (accident or near accident)

The establishment of the terminal or feared event is a fundamental step in the construction of the tree. We understand that the more detailed this event is specified, the easier it will be to construct the cause tree. It is essential to examine the direct, necessary, and sufficient (DNS) causes from this final event (figure 10). In other words, it is relevant to consider the following questions:

- What cause(s) or event(s) was/were necessary to achieve this consequence?
- Is this cause sufficient to bring about this consequence?

The systematic search for immediate, necessary, and sufficient (INS) causes is therefore the basis for constructing the tree.

This approach allows for a detailed cause tree that is valuable for analysis and information gathering. After the analysis, one can choose to keep only the verified causes in a simplified representation that reflects the most probable scenario.

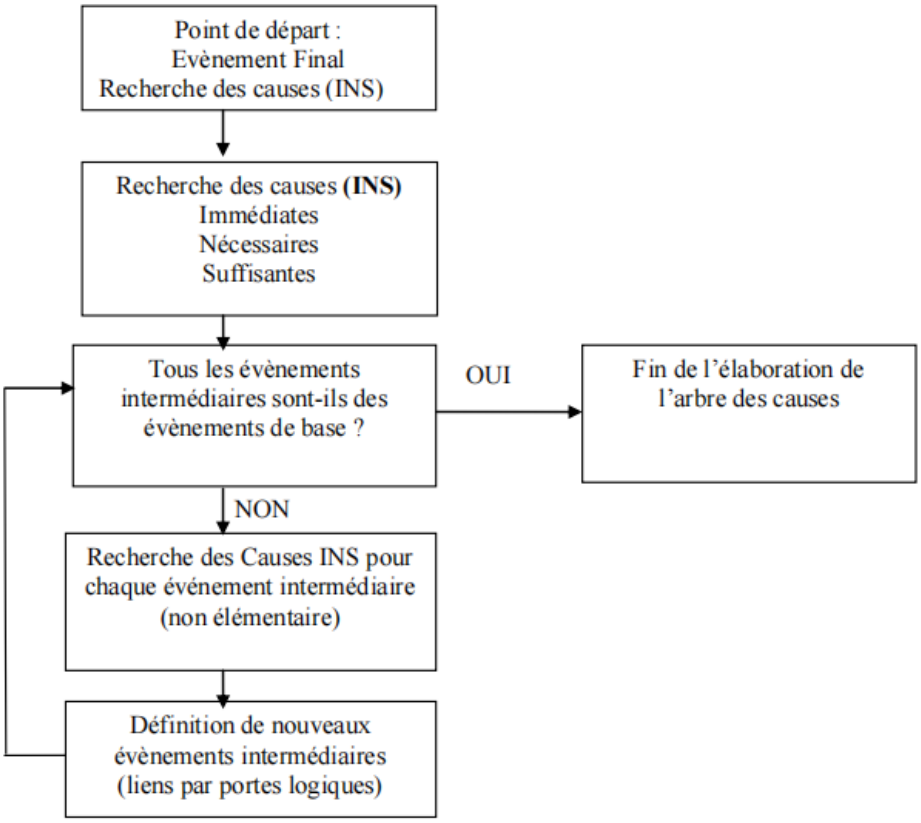


Figure 10: Steps for creating a cause tree

II.3.3.4.2. The Ishikawa diagram or cause-and-effect diagram

This tool allows for highlighting, categorizing by family, and prioritizing the causes of a given effect. It facilitates consensus on the most important causes. It helps to rough out a problem in the absence of numerical data. The diagram is based on group work and is developed in several stages (figure 11):

1. Clear description of the problem.

2. Conducting a brainstorming session, determining the main categories of causes. Often we use a set of categories that we call the 5Ms: Workforce, Material, Environment, Equipment, Methods.

3. Tracing the skeleton of the Ishikawa diagram and writing the categories on it.

4. For each category, write down the causes suggested by the group members by repeatedly

asking the question: why does this cause produce this effect?

5. Classification, if possible, of the suggested causes into sub-categories.

6. Determination of the root causes that can be eliminated.

7. Actions on the cause(s) to correct the defect by proposing solutions and implementing corrective actions.

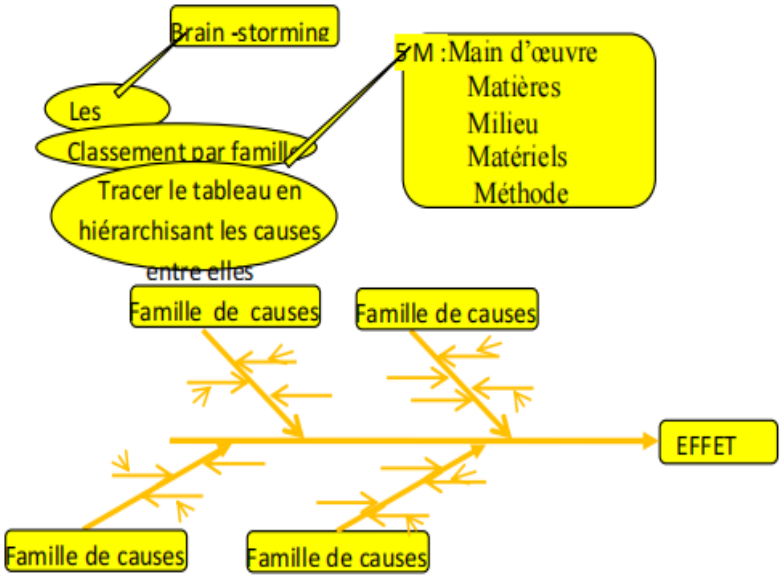


Figure 11: Ishikawa Diagram

Chapter III: 5Ms theory

III.1. Theory of the 5Ms

The causes of an accident / incident are to be sought under the following aspects that describe an activity:

1. Labor ; **2.** Materials (resources, energy, fluids, goods, and manufactured products);

3. Environment (temperature, humidity, vibrations, ...) ; **4.** Equipment;

5. Method (of work, manufacturing commitment, maintenance, …).

Finding the causes involves determining what could have produced the effect, based on the concept of the 5Ms (figure 11).

III.2. Information circulation

- The investigation report is completed and signed by the two people (immediate supervisor and worker representative) who conducted the investigation.

- Circulation of information and distribution of the report: A copy of the report is sent for information to all the people who are concerned by the various corrective or preventive measures that are suggested. At a minimum, copies must be sent:

- To the head of the department where the accident occurred so that they can inform the people working within that department;
- To the human resources department or the general management of the company (depending on the size of the company) for the management of the file at the health and safety committee.

III.3. Follow-up of recommendations

The responsibilities related to monitoring the proposed corrective and preventive measures are shared among the various concerned departments.

- The corrective measures to be taken immediately are the responsibility of the immediate supervisor of the employee who was the victim of the accident;
- The preventive measures (those suggested from a long-term prevention perspective) are the responsibility of the department head where the accident occurred.
- Communication: each person responsible for implementing a corrective or preventive measure must notify the health and safety committee of any information regarding the follow-up to be done or the measures already taken. This allows the committee to ensure that all necessary measures have been taken to prevent the recurrence of similar events.

III.4. Employer's responsibility

The company manager must receive a complete report regarding all accidents that occur at work (e.g., accident notice, investigation report, recommendations, follow-up). If he assesses that the information transmitted to him is incomplete, he must demand that the report be redone.

III.5. Development of recommendations

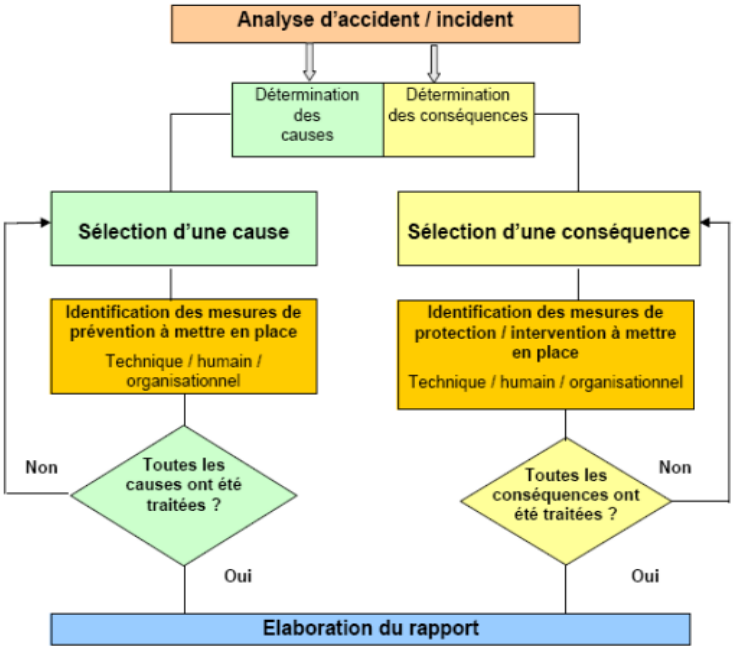


Figura 12: Analizar accidente / incidente

III.6. Hygiene control in the food industry

III.6.1. Definition

Set of conditions and measures necessary to ensure the safety and wholesomeness of food at all stages of the food chain. We therefore observe that food hygiene has two components: food safety and food wholesomeness.

III.6.1.1. Food safety

The term "security" (in Latin, *securitas*) refers to a confident and tranquil state of mind of someone who believes themselves to be safe from danger. This term is now used to ensure the safety of food under the notion of "food safety."

Safety refers to *"a confident and peaceful state of mind of someone who believes they are safe from danger"*. For our purposes, this term is used to ensure the safety of food under the notion of "food safety." It is the assurance that food will not cause harm to the consumer when prepared and/or consumed according to its intended use. Food security is an experience that refers to the security of food supplies.

III.6.1.2. The wholesomeness of food

The concept of wholesomeness is different from that of safety. It applies more to the intrinsic characteristics of the product, namely taste, smell, texture, presentation, with the presence of spoilage microbes (bacteria, yeasts, and molds), for example. The notion of safety is therefore stronger than that of wholesomeness, but the results are identical: losses. In one case (unsanitary conditions), we can lose the product, and in the other case (insecurity), we can lose the consumer's trust. These two components of hygiene are inseparable; the notion of wholesomeness is different from that of safety. It applies more to the intrinsic characteristics of the product, namely taste, smell, texture, presentation, with the presence of spoilage microbes (bacteria, yeasts, and molds).

In other words, it is the assurance that the foods, when consumed according to their intended use, are acceptable for human consumption. The notion of safety is therefore stronger than that of wholesomeness, but the results are identical: losses. In one case (unsanitary conditions), we can lose the product, and in the other case (insecurity), we can lose the consumer.

III.6.2. 5M method

III.6.2.1. How are microorganisms introduced into food?

Microorganisms are naturally present everyplace, they play an essential role in nature. From the Neolithic period onward, foods fermented by naturally occurring microorganisms were recognized for their better preservation, and developments have continued ever since.

Some microorganisms will be accidentally present in the food and can cause food spoilage or pathology that can even lead to the individual's death. It is interesting to understand how these microorganisms are introduced into food, whether they are useful for production or not.

Whatever the microorganism, it is always introduced into food during one of the 5 M: Labor, Equipment, Environment, Raw Material, Method.

The floras are differentiated into initial, exogenous, or technological floras (figure 13).

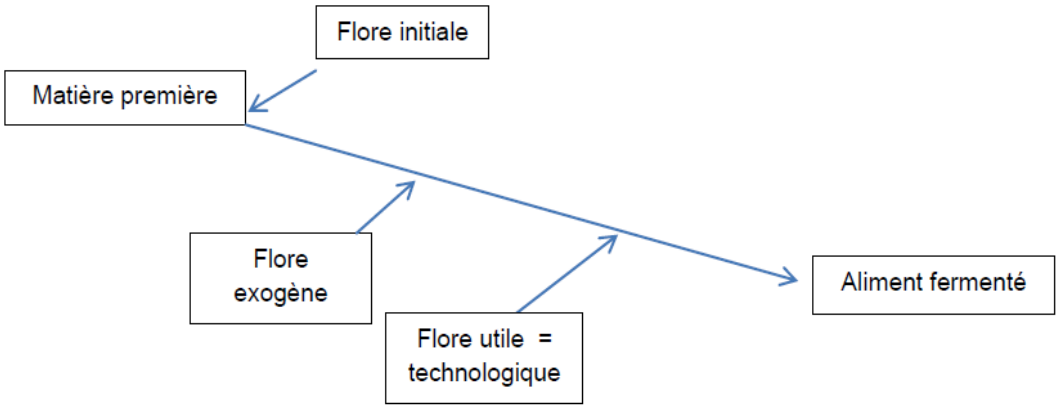


Figure 13: The floras are differentiated into initial, exogenous, or technological floras.

III.6.2.1.1. Initial flora

This is the flora that is naturally present in the food product. This flora is introduced into the manufacturing process during the addition of the product, which corresponds to the "raw material" level of the 5 M.

Foodstuffs are not sterile and are in contact with the external environment, so they carry microorganisms that are introduced into the manufacturing process (figure 14). These microorganisms may be of interest for the upcoming transformation (for example, the microorganisms in milk to make cheese such as Comté) or not.

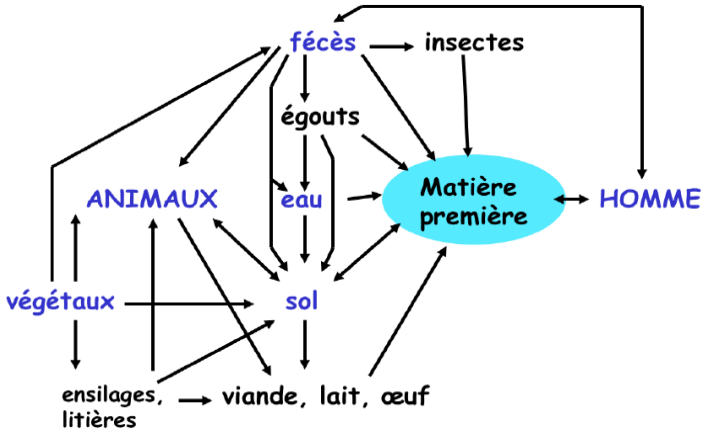


Figure 14: Origin of microorganisms present in the raw material

III.6.2.1.2. Exogenous flora

Exogenous flora is the so-called contamination flora. This can be introduced during the intervention of the "workforce," during the use of "equipment," or due to the "environment."

a. Labor

The staff carries many germs (figure 15), so they can contaminate food thru their clothes, saliva, hair, body hair,… The hygiene of workers is therefore a very important point.

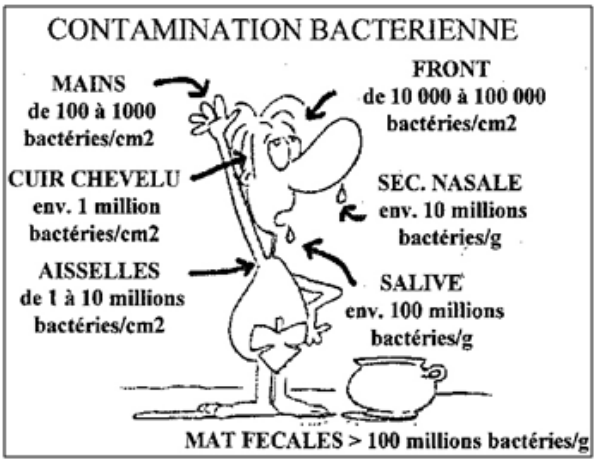


Figure 16: Staff contamination

b. Equipment

All the equipment used in the production of a food product is not sterile and therefore introduces additional flora. A good cleaning and disinfection are necessary to avoid this influx.

c. Environment

The microorganisms in the environment can come from the air or from pests (i.e., rodents, insects, or arachnids).

III.6.2.1.3. Useful or technological flora

This flora is of interest for the product and is added to the "method."

d. Method

Microorganisms are added during the food manufacturing process because they are beneficial

to the product, particularly the microorganisms used for fermentation. In the context of fermentation, microorganisms are called ferments: these can be molds, bacteria, or yeasts.

They are necessary for the production of specific products for which a particular organoleptic aspect is sought.

Indeed, the microorganisms used to carry out fermentation metabolize, in aerobiosis or anaerobiosis, substrates of different natures (carbohydrates, lipids, proteins) and thus affect the properties of a food.

The aim of fermentation is to modify one or more of the following characteristics: flavor, acidification, texture, external appearance, nutritional properties, stabilization, and preservation.

The selection process of ferments is complex, will be based on technological properties depending on the characteristics of the fermented product, and must meet criteria for preservation and compatibility with other microorganisms possibly present in the product (figure 16).

III.6.3. Guide to Good Hygiene Practices (GBPH)

III.6.3.1. Definition

Good hygiene practices concern all operations aimed at ensuring hygiene, that is, the safety and wholesomeness of food. BPH includes operations whose consequences for the finished product are not always measurable.

Good hygiene practices (GHP) or prerequisite programs (PRP) concern all operations aimed at ensuring hygiene, that is, the safety and wholesomeness of food. The PRP (or general principles of hygiene according to the Codex) include operations whose consequences for the finished product are not always measurable. PRPs provide a solid foundation that ensures food hygiene and should, if necessary, be used in conjunction with each specific code of practice for hygiene, as well as with regulations and directives governing microbiological criteria.

They apply to the food chain from primary production to final consumption, indicating the hygiene controls to be implemented at each stage. The guides to good hygiene practices (GBPH) are a reference framework that is primarily based on the cause-and-effect diagram, also known as the Ishikawa diagram (figure 17), which is a simple and effective graphical representation of all the causes and their effects.

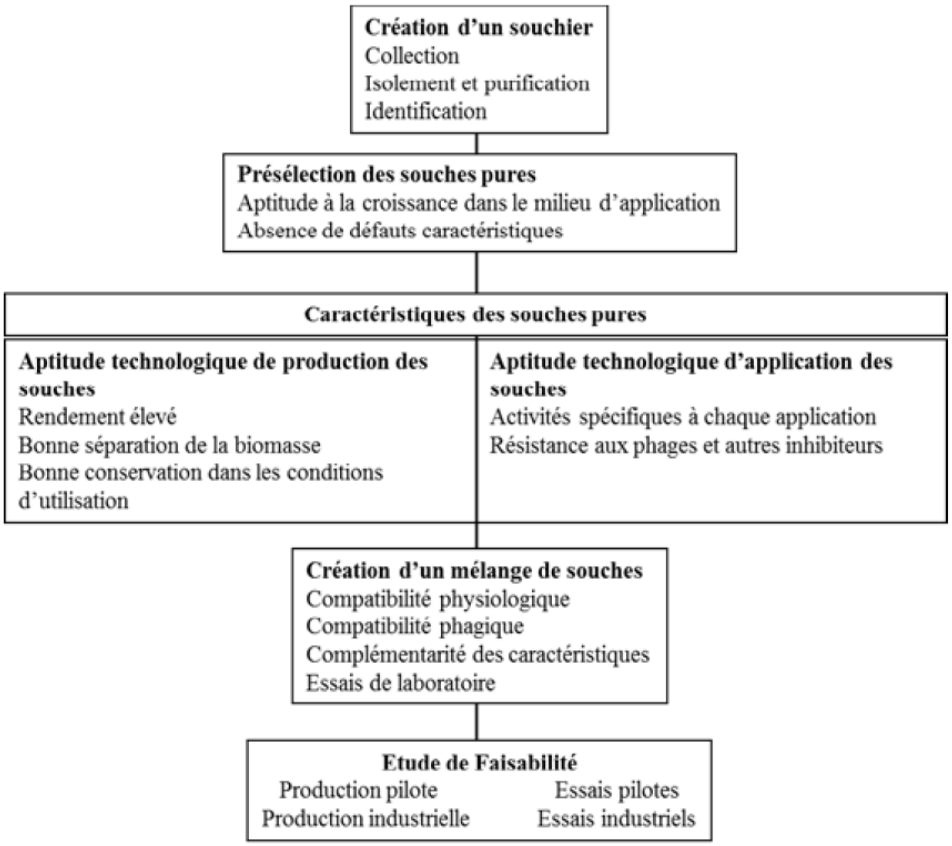


Figure 16: Strain selection phase

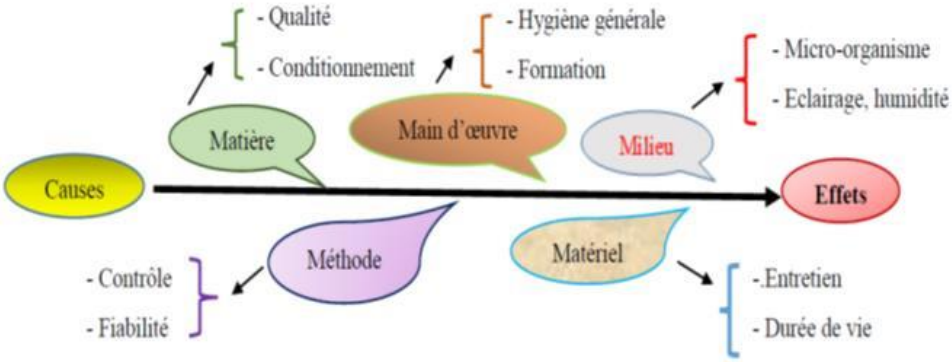


Figure 17: Cause-effect diagram

The hygiene requirements that apply in the food processing industries are commonly referred to as prerequisite programs (PRP) or good hygiene practices (GHP). Good hygiene practices (GHP) are generally grouped into different categories: personal hygiene, hygiene related to transport and storage, cleaning and disinfection, premises hygiene, pest control, waste management.

III.6.3.2. The different sections of good hygiene practices (GHP)

III.6.3.2.1. Personnel hygiene

Upon hiring at the company, any person assigned to work and handle products is subject to a medical examination by the company's contracted physician. This person issues a medical certificate to anyone who is healthy and ensures their medical follow-up at least once a year. If necessary, especially during follow-up visits, he also raises awareness about the rules of personal and clothing hygiene. The hygiene manager is responsible for educating all newly hired individuals on the hygiene rules to follow.

III.6.3.2.2. Hygiene of storage areas

They should be isolated from production areas and must be cleaned regularly. The layout of the storage racks must allow for cleaning. They must be in good condition, dry, ventilated, and weatherproof. Toxic products essential for the company's operation must be stored in a separate room equipped with a retention system. No contamination of the storage and production areas should be possible.

III.6.3.2.3. Transportation and establishment

The establishments must make sure that the first materials, food products shipped, and other items received are transported and maintained in a way that prevents any physical, chemical, or microbiological contamination.

III.6.3.2.4. Desinfection and cleaning

The TACT procedure (Temperature, Action mechanical, Concentration, and Temperature) must be followed when cleaning and disinfecting.

III.6.3.2.5. Equipment hygiene

The establishments must use equipment designed for food production and have it installed and maintained in a way that effectively prevents food contamination.

III.6.3.2.6. Trash manager

Food waste and other waste materials are stored outside of areas where food products are stored and handled.

III.6.3.2.7. The struggle against the harmful

Raticides, insecticides, disinfectants, and other compounds that may be harmful must be placed in closed areas and cabinets and used in a way that does not contaminate food products.

III.6.3.3. Food safety, hygienic practices, and salubrity

One definition of hygiene would be the collection of all the precautions and requirements needed to control the risks and ensure that a food is safe for human consumption based on its intended use. Additionally, it aims to guarantee food safety and salubrity at every stage of the food chain.

Furthermore, it should be noted that "food hygiene" is a medical term that refers to the rational selection of foods (nutrition, diet), and it should not be confused with "food hygiene," as defined here. Therefore, we see that food hygiene consists of two parts:

III.6.3.3.1. The ISO 22000 standard

The purpose of the ISO 22000 standard is to establish a model for the management of food safety that incorporates both the foundational elements of the HACCP system and the Codex Alimentarius, as well as the elements related to the management system itself.

a. The introduction of ISO 22000

ISO 22000 is well-known and used on a global scale. She still lives with other private references, but she has found her place. She should conclude by asserting that it is the only and only document that can coherently compile all the elements involved in understanding and managing food safety:

- Surveillance and adherence to regulations; prerequisite programs (PRP);
- Internal and external communication;
- The HACCP method with an understanding of PRPo and CCP;

- Traceability; product recall and/or withdrawal; competency management;
- The handling of emergencies and crises;
- The ongoing progress.

b. The benefits of ISO 22000

Two benefits of ISO 22000 are as follows: a global SMSDA approach for an effective risk assessment. It applies to all parties involved in the food chain.

There is broad agreement on an international standard. The ISO 22000 standard was designed to be harmonious and compatible with other international management system reference standards, such as ISO 9001. As a result, she may seamlessly integrate into the company's management and operational processes.

Any organization directly or indirectly involved in the agro-food industry is subject to ISO 22000. It makes it possible to assess and prove the product's compliance with food safety regulations and to demonstrate the control exercised over food risks. The reference covers food safety based on four internationally accepted principles:

- Interactions in communication

The purpose of ISO 22000 is to identify all relevant food safety hazards at every level of the food chain so that they can be properly maintained. It also emphasizes the value of communication both internally, aimed at the organization's members, and externally, between suppliers and customers.

- System management

This principle is based on the integration of all food safety management systems into a single structured management system that takes into account other general organizational management activities.

- Prerequisite programs (PRP)

According to the Codex, PRP, also known as general hygiene principles, provide strong

foundations that enable ensuring food hygiene and must be used in conjunction with each code of use for hygiene-related matters where necessary.

They enable the maintenance of proper hygiene throughout the production chain and ensure that the final products are safe for human consumption. These PRP must be set up prior to any production activity.

The implementation of these PRPs enables the analysis and management of risks and their definition in PRPo or CCP. In this way, the appearance of hazards is minimized.
The purpose of PRP is to maintain a hygienic production, treatment, and/or manipulation environment rather than to control the identified and specific risks.

III.7. Safety and hygiene in the laboratory

III.7.1. Appropriate laboratory practices

Good laboratory practices (BPL) are the foundation for a laboratory's cleanliness, security, and quality of results. The BPL establishes a **quality assurance system** based on the **way nonclinical security studies** that address health and the environment are organized, as well as the circumstances under which these studies are planned, carried out, controlled, recorded, archived, and disseminated.

One component of quality assurance is the BPL, which ensures that products are manufactured and controlled consistently, in accordance with quality standards specific to their use and specified in the authorization to be put on the market. Bonnes pratiques laboratoires (BPL) are the set of guidelines to follow when conducting tests (physico-chemical properties, toxicological studies, eco-toxicological studies, etc.) and manipulating a product (biologic, pharmaceutical, pesticide, food additives, cosmetics, industrial chemiques, etc.).

Quality in the laboratory can be defined as fairness, reliability, and ability to present analysis results. In order to be used for clinical or public health purposes, laboratory results must be as precise as possible, all laboratory activities must be feasible, and the results must be reported accurately.

The American Food and Nutrition Organization defines quality as "a product or service whose characteristics permit it to satisfy the expressed or implicit needs of consumers."

Therefore, quality is a relative concept based on need. In general, one should look for both the best and highest quality while adhering to the QSE (quality, effectiveness, and security).

III.7.1.1. BPL objectives

The goals of the BPL are to ensure the consistency and traceability of study results, as well as to encourage international recognition of studies conducted in member countries to prevent duplication and ensure credibility.

External factors include:	Internal issues include:
- International recognition;	- Employee mobilization;
- A strong external image;	-Organization and resource optimization and rationalization;
- Customer satisfaction and identification;	- Daily management through procedures;
	- Reduction of non-qualities;
- Addressing emerging needs	- System improvement.

III.7.1.2. The BPL application fields

Procedures and protocols, installations, equipment, supplies, reactive materials, personnel and organization, and study and reference products are all areas where BPL is used.

III.7.1.3. The BPL principles

The BPL principles in a laboratory "analyses of chemistry" have been implemented through the study of the impact of the 5 M (materials, equipment, methods, environment, and principal action) (figure 18), which include: setup and staff of the experimental installation; quality assurance program; installations; equipment, materials, and reactives; systems of the experiment; elements of the experiment and of reference; normalized operating procedures; execution of the study; creation of a report on the study's findings; storage and preservation of the archives and materials.

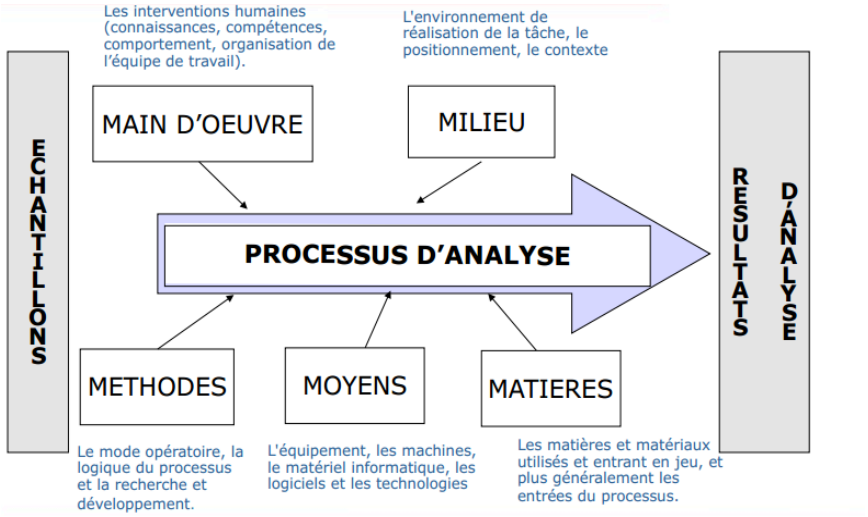


Figure 18: Laboratory modelization

III.7.1.4. The BPL's recommendations

- Possessing a solid understanding of the work to be done;
- Establishing a laboratory organization;
- Guaranteeing the quality of the measurements;
- Organizing documentation and traceability;
- Ensuring that personnel follow procedures and operating methods;
- Ensuring that reactive materials are readily available, non-perimés, and stored in conditions specified by the manufacturer;
- Ensuring periodic verification, cleaning, maintenance, and etalonnage with pertinent operations;
- Verifying that the laboratory's equipment, installations, and instrumentation are operational;
- Verifying that environmental factors are not likely to impact results or interfere with the operation of the devices;
- Respecting the security protocol;
- Acting appropriately in the lab;
- Protecting oneself and others;
- Labeling and properly storing chemical products;
- Correctly disposing of waste while taking all necessary precautions to prevent contamination.

III.7.2. Individual protective equipment

The purpose of personal protective equipment is to limit an employee's exposure to one or more forms of risk to a level that is acceptable. Before each use, the EPI must be properly stored and inspected. A defective EPI does not provide the required protection (figure 19).

Les EPI sont des «dispositifs ou moyens portés par une personne en vue de la protéger contre les risques susceptibles de menacer sa santé et sa sécurité». Ils sont utilisés après la mise en place de protections collectives.

En SVT ou en biologie écologie, les EPI sont principalement utilisés lors des séances de travaux pratiques. Leur choix raisonné varie en fonction des risques encourus.

Les gants de protection

Le port de gants de protection est une mesure de prévention aux atteintes de la peau, des poignets, des mains et aux contaminations par contact.

Selon leur nature, les gants de protection protègent les mains et les poignets contre un risque :

- mécanique, lors de la manipulation d'un objet coupant ou pointu ;
- thermique, lors de la manipulation d'un produit très chaud ou très froid ;
- chimique, lors de la manipulation d'un produit nocif ;
- biologique, lors de la manipulation de micro-organismes.

Les gants utilisés ne doivent pas être nocifs pour l'utilisateur. Le port de gants de protection n'est pas systématique lors de la manipulation de micro-organismes de groupe 1.

L'utilisation de gants de protection ne dispense ni d'un lavage des mains avant et après manipulation, ni des précautions nécessaires pour éviter les blessures.

La blouse en coton

La blouse en coton offre une protection contre les pollutions et/ou les dégradations des vêtements personnels. Étant moins inflammable que les matières synthétiques, elle protège l'utilisateur en limitant les risques de brûlures lors d'un usage inapproprié d'une flamme. Pour offrir une protection maximale, sa taille est adaptée à celle de l'utilisateur. Elle est fermée par des boutons-pression ou par un nombre suffisant de boutons.

Le port de la blouse en coton est indispensable lors des séances de travaux pratiques manipulatoires dans une salle dédiée.

Figure 19: Safety precautions in a chemical laboratory

III.7.2.1. Laboratory safety equipment

The safety precautions that can be found in a chemical laboratory include: First-secours douche fixe (or security douche) mural rince-oeil (ocular) (figure 20).

Figure 20: Security measures

The various tools used to ignite a fire (figure 21) include:

- **Water** that stirs through cooling;

- **The powders** and **sand** that act by suffocation;

- **Les mousses** that suffocation acts;

- When used as carbonic snow, **CO_2** (dioxyde of carbon) stirs by heating or cooling. Some of the extinctor's components (such as the goupille, transport poignée, debit controller, etc.) are colored to make it easier to identify the agent contained in it.

Figure 21: Correspondence between fire classes and different extinguishing agents

- CO_2 extinguishers (red handle). Liquid fires (alcohols, organic solvents, oils, greases), but also fires involving electronics and computer equipment.

- Powder extinguishers (yellow handle). Metal fires (sodium, magnesium, etc.) and gas fires (propane, town gas).

- Water extinguishers (blue handle). Fires involving solid materials (wood, fabrics, cardboard, paper).

III.7.3. Sources of danger in a laboratory

For dairy processing specialists, the major risk is the infection of products by pathogens, the proliferation of harmful microorganisms—or the appearance of toxins generated by some

of them—as well as the significant presence of micropollutants in the products. Consumption of this product therefore leads to foodborne illness.

It is referred to as a toxi-infection or mass food intoxication (TIAC) when a number of consumers of the same food are impacted. A few may be reported by the media, informing the concerned businesses as well as all parties involved in the chain of commerce. The consumer may express doubts about the products' quality and show hesitation in purchasing them.

Animals, the environment, primary materials, or human beings can all produce microorganisms or infectious agents that are capable of spreading germs. The conditions of manufacture, transformation, transportation, and marketing may create an environment that is favourable to the rapid proliferation of these microorganisms if the products are delivered at room temperature.

Other risks include the presence of chemical residues in the skin, such as residues of pesticides, antibiotics, or even heavy metals, as well as other contaminants found in the skin or other primary materials.

The following are the threats to be controlled: physical, chemical, and microbiological. Finally, the culinary industry professionals are aware of the particular susceptibility of specific groups to food-related infections: young children, the elderly, and pregnant women in particular. However, certain benign diseases can develop into more severe forms. Only a small number of microorganisms can cause a severe form of the disease, although a healthy individual would not get the disease from eating the same food.

III.7.3.1. Chemical danger

Certain chemical pollutants may be present in the products we eat and pose a risk to our health. However, it is important to note that, in contrast to microbiological danger, chemical danger has a cumulative effect. This means that the consumer is not ill when they first consume the product, but repeated consumption may result in health issues (cancers from repeated pesticide dosages, the emergence of bacteria resistant to antibiotics, etc.).

Furthermore, the presence of chemical pollutants can cause technological issues. For instance, a milk containing antibiotics neutralizes the activity of ferments and prevents yogurt from coagulating.

Safety imperatives and responsibility education objectives associated with these operations:

- Personal safety, by identifying hazards (clear and up-to-date signage), reducing risks by substituting hazardous chemical agents and organizing storage;
- Environmental protection, by ensuring appropriate waste management and disposal.

III.7.3.1.1. Rules to be followed

- Operators must have access to the safety data sheets (SDS) for chemical products;
- Chemicals must be handled with caution;
- For hazardous substances, non-hazardous or less hazardous substitutes are used whenever possible;
- It is essential to provide recovery bottles following experimental activities.

III.7.3.1.2. Best practices

- Label all bottles;
- Provide handlers with a binder containing safety data sheets for consultation or label design;
- Display hazard pictograms in each experimental science room;
- Use a fume hood when handling certain products or mixtures;
- Check the necessary personal protection equipment based on the classification of the chemical used and the specific concentration limits;
- Identify what can be disposed of down the sink and what must be recovered;
- Provide labeled temporary recovery bottles to prevent mix-ups.

III.7.3.1.3. Storage of chemicals

III.7.3.1.3.1. Consider product compatibility

Products must be separated by hazard class (acids, bases, oxidizers, flammables, toxics, etc.) given the incompatibility of some products with each other. Here is a table showing the possible combinations and those to absolutely avoid when storing hazardous products:

Table 1: Chemical compatibility

	Je flambe	Je fais flamber	J'explose	Je ronge	Je tue	J'altère la santé ou la couche d'ozone
	+	X	X	X	X	+
	X	+	X	X	X	O
	X	X	+	X	X	X
	X	X	X	O	X	X
	X	X	X	X	+	+
	+	O	X	X	+	+

+ compatibles
X incompatibles
O compatibles sous conditions particulières

Toxic, flammable products and concentrated acids and bases must be stored in a specific cabinet, either filtered or ventilated, which can be locked. Each compartment of the cabinet must be identified using warning signs (it may also be useful to specify where the acids and bases are for compartments containing corrosive products) (figure 22, 23).

All products stored in the laboratory must be clearly identified by regulatory labeling. The information to be indicated on the labels (figure 24) must include the following:

- Product designation (name, chemical formula, and concentration);
- Packaging (volume or mass);
- Standardized hazard pictograms;
- Standardized risk phrase numbers and safety precautions (R and S phrases).

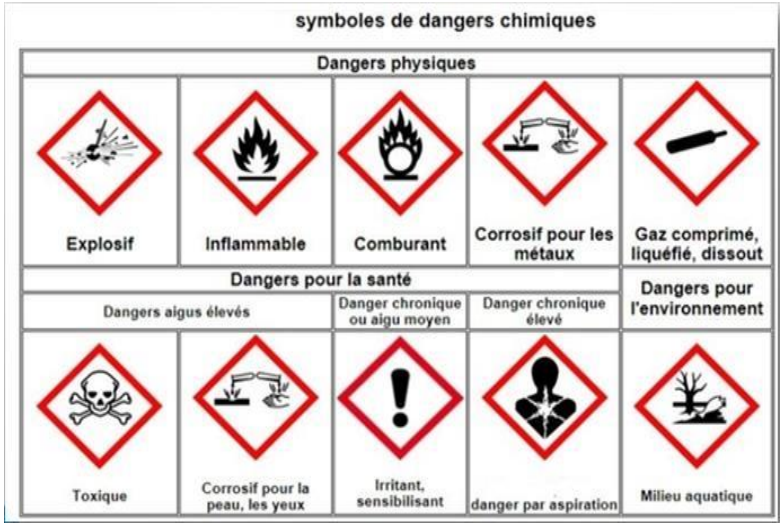


Figure 22: Safety pictograms

Figure 23: Safety cabinet

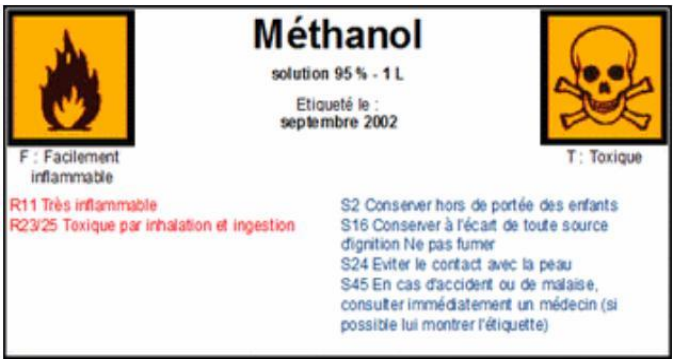


Figure 24: Methanol labeling

The following information can also be included:

- The manufacturing date (especially for solutions that cannot be stored for a long time).
- The wording of the R and S phrases.
- Pictograms for safety measures (wearing goggles, using an extractor hood, etc.).
- The official classification numbers (CAS, EC, Index).
- The product's physicochemical constants (molar mass, density, etc.).
- The manufacturer's contact information.
- Keep a record of stored products.
- It is also important to have the safety data sheets (or SDS) for all stored products available. Ideally, you should have a precise list of products by storage area, as well as a collection of the SDSs for the corresponding products.

III.7.3.1.3.2. Safety instructions

If you are present during an accident, fire, or any other risky situation, you should never

put yourself in danger, even to assist a victim. On the contrary, you must protect yourself, protect the victim, and prevent further accidents. Remember the following principle: protect - alert - rescue.

a. Safety instructions in the event of a chemical spill

- Remove all sources of ignition;
- Evacuate adjacent areas if the room is small or cannot be easily ventilated, and limit access to authorized personnel;
- Open windows;
- Activate fume hoods if the spill occurs in a laboratory;
- Leave the area and close the door when leaving;
- Prevent access to the room;
- Post a sign indicating that re-entry is prohibited;
- Alert the security control center;
- If the spill is large, external emergency services will take charge of the cleanup.

In the event of a small spill, to clean up the spilled product: Wear appropriate protective equipment: lab coat, gloves (thick neoprene), safety goggles, ABEKP cartridge mask.

- If there is a risk of spillage into the sewer, install a plug or other system to prevent discharge into the sewer (sock, etc.);
- Absorb the product with an inert absorbent material (vermiculite, sand, special absorbent paper);
- Using a shovel, collect the absorbent and place it in a tightly sealable container. Label this container for disposal as chemical waste;
- Wash the contaminated area with water (recover the wash water for disposal where possible).

Goggles and respiratory protection masks are personal equipment that cannot be loaned. If swallowed: do not induce vomiting, do not drink anything, no milk.

b. Safety instructions in the event of chemical splashes

<u>In the event of chemical splashes on clothing</u>

- Remove clothing soiled by the product;
- Rinse yourself under a safety shower or under running water for approximately 15 minutes;
- Report the accident or incident to the prevention assistant to record the event in the occupational health and safety register.

In case of chemical splashes on the skin

- Alert the nearest first help;
- Alert the safety command post;
- Remove any clothing soiled by the product;
- Wash the skin under a safety shower or under running water for 15 minutes;
- Do not use detergents, creams, etc.
- Consult the prevention medicine department;
- Report a workplace accident within 24 hours of the accident in case of injury;
- Report the accident or incident to the Prevention Assistant to record the event in the occupational health and safety register;
- Notify the Health and Safety Department of the incident or accident;
- Consult the prevention doctor and report any symptoms occurring in the days following the incident or accident.

In case of chemical splash in the eye

- Alert the nearest first help;
- Alert the safety command post;
- Rinse with an eye rinse or under running water or in a shower, keeping the eyelids apart, head tilted and the affected eye facing down, for at least 15 minutes;
- Do not remove contact lenses;
- Do not use eye drops or eye solutions;
- Consult an ophthalmologist urgently;
- Report a workplace accident within 24 hours of the accident in case of injury;
- Report the accident or incident to the Prevention Assistant to record the event in the occupational health and safety register;

- Notify the prevention doctor and the Health and Safety Department of the incident or accident;
- Consult the prevention doctor and report any symptoms occurring in the days following the incident or accident.

III.7.3.1.4. Chemical contaminants

III.7.3.1.4.1. Drug residues in milk

Any animal receiving medical care can potentially release the drug's active ingredient through its meat or milk.

The detection of antibiotics (veterinary inputs) in milk represents a potential risk to consumer health. Indeed, the digestive tract is home to billions of saprophytic and commensal bacteria. By occupying this environment, they promote the establishment of a natural immune system through the generation of antibodies. This mechanism blocks the proliferation of many pathogens.

The use of antibiotics (cycline, sulfonamide) disrupts this intestinal flora, reducing existing natural immunity and potentially causing damage to the nervous system, bones, teeth (which can turn yellow), liver, and blood. In addition, it can promote the growth of mutant bacteria resistant to antibiotics, leading to treatment failures.

Furthermore, milk containing antibiotics or traces of antibiotics is not suitable for making yogurt or cheese, as this requires the cultivation of certain bacteria (such as *Lactobacillus* in the case of yogurt). Milk containing antibiotics creates an unfavorable environment for germs. When inoculated with a starter or ferment, the bacteria may die or weaken, which can lead to fermentation problems: for example, the yogurt may not coagulate successfully, the yogurt will not "set" and will remain liquid.

In the field of animal husbandry, antibiotics can be used for therapeutic purposes (to treat a bacterial infection in animals), preventive purposes (to avoid infections and diseases of bacterial origin) and as growth accelerators (to optimize digestibility or facilitate the absorption of animal feed).

The time required for the animal's body to completely eliminate chemical residues from the treatment is specified in the instructions for use of veterinary drugs. During this period, it

is prohibited to use or consume these products (meat and milk).

Milk contaminated with antibiotics can be detected, either by not respecting the withdrawal periods or by using fraudulent methods (adding antibiotics for preservation during transport), using rapid tests. However, dairies do not have access to these types of tests. Furthermore, milk contaminated with antibiotics can only be suspected in the case of a technical incident (such as yogurt that does not set properly or defective coagulation, for example).

III.7.3.1.4.2. Cleaning and maintenance products

Cleaning and disinfecting products used for the processing unit's space and equipment can also be harmful. They must be stored in a dedicated cabinet and properly labeled. It is imperative that personnel wear gloves when using these products. It is essential to strictly follow the prescribed doses and to systematically rinse with water.

III.7.3.1.4.3. Other chemicals

a. Chemical residues in animal feed

A pesticide is a product used to control organisms harmful to humans. They are categorized into different classes: insecticides, fungicides (intended to control fungi), herbicides, zoocides, acaricides (to control mites), rodenticides (to destroy rodents), bactericides, algaecides, and so on.

The promotion of intensive or industrial agriculture is largely based on the use of these products. Therefore, once applied, a pesticide can end up in various environmental matrices and come into contact with animals through various routes. Milk may contain traces of pesticides, as cows can be exposed to these substances through the following means:

- The use of plant protection substances directly on animals. For example, the application of external pest control products;
- The digestive tract through the consumption of food and water containing pesticides;
- The air the animal breathes.

Chemical contaminants (particularly pesticides) can cause two types of hazards:

- Hazards to animal health through overdose or accidental ingestion;
- Hazards to human health through contact with animals and/or ingestion of contaminated animal products.

Food ingestion is not the only means of chemical contamination. Indeed, certain molecules from industries (PCB20) or from the combustion of hydrocarbons and other waste (furans and dioxins) can penetrate the respiratory tract and skin. There is little information regarding the dangers associated with the presence of pesticide residues in milk. It has been shown that some organochlorine pesticides can contaminate the milk of farm animals even ten years after their application.

b. Heavy metal residues or metallic trace elements

All heavy metals have some toxicity to humans. They are found everywhere in our environment: in the air, water, soil, and living beings. Cyanide, lead, cadmium, and mercury are heavy metals that are exclusively toxic. Exposure to the majority of heavy metals occurs primarily through the consumption of contaminated food, in addition to drinking water and air.

There is a real risk of accumulation of these potentially harmful compounds in livestock through the ingestion of contaminated food. Milk and dairy products can also be contaminated and cause harm when ingested in large quantities.

Heavy metals such as cadmium, mercury, lead, and zinc are frequently tested for in milk and cheese.

c. Nitrites, Nitrates, and Nitrosamines

The production of certain dairy products involves the addition of nitrates to the milk used to curdle. They are mainly found in whey. Nitrites resulting from the transformation of nitrates can produce nitrosamines, some of which have carcinogenic properties. It is therefore advisable to follow the manufacturer's dosages and instructions.

III.7.3.2. Waste

Whenever possible, treat your waste in a way that transforms it into non-hazardous

products. Consider waste treatment as a chemical reaction.

- Used solvents: Chlorinated and non-chlorinated solvents are mixed and stored in emptied containers.

- Aqueous solutions: If they do not present any risks (to humans or the environment), they are disposed of down the sink. Otherwise, they are treated as toxic waste. The pH must be between 7 and 8.2. Do not use toxic or foul-smelling products.

- Toxic waste: If they cannot be destroyed and converted into non-toxic waste, bottle them, label them (date and type), place a piece of parafilm around the cap, and place them in the bunker in boxes filled with vermiculite. Report this to the health and safety managers. A shipment takes place at least once a year (more frequently depending on demand).

- Old products: If they cannot be destroyed safely, treat them as toxic waste. Radioactive scintillation: Do not dispose of any solvents, even those with low levels of radioactive activity: treat them as conventional radioactive waste.

III.7.3.3. Microbiological hazard

This is the main threat to manage during milk processing. Potential sources of pathogens in food can be diverse, primarily including animals, the environment, and equipment, as well as facility personnel or visitors who come into contact with the products.

During experimental activities, operators may be required to handle microorganisms. Microorganisms are classified into four groups: Group 1: microorganisms presenting no or negligible risk; Group 2: microorganisms presenting a low risk; Group 3: microorganisms presenting a moderate risk; and Group 4: microorganisms presenting a high risk.

III.7.3.3.1. Infectious agents from animals

A sick animal can potentially spread a pathogenic microorganism through its milk or flesh. In particular, animals affected by tuberculosis or brucellosis produce milk infected with pathogens, namely *Mycobacterium* sp. and *Brucella* sp. Mastitis, whether clinical or subclinical, can also cause milk contamination.

Therefore, processors who purchase milk from livestock farmers generally cannot guarantee that the milk they purchase is free from these bacterial contamination. It is

recommended to systematically pasteurize milk intended for processing to eradicate these infectious agents.

a. Tuberculosis

Definition

The causative agent of tuberculosis is the bacterium *Mycobacterium tuberculosis*, which affects cattle. This bacterium is also harmful to humans and is spread through unpasteurized milk. Tuberculosis is legally recognized as a contagious disease (CRD).

Mode of transmission

There are several ways in which tuberculosis can be transmitted to humans:

- Introduction of the microbe through a skin lesion or contamination of the ocular membrane (this mode of transmission poses a risk to farmers, veterinarians, and slaughterhouse employees);
- Inhalation of dust (from contaminated slaughterhouses and farms) during cleaning activities or other procedures;
- Consumption of contaminated products (meat, milk) and derivatives (this mode of transmission poses a risk to consumers of milk or dairy products infected with the bacteria).

Symptoms in humans

This disease causes specific lesions, called tubercles, which are mainly located in the lungs. However, other forms of tuberculosis may also be present. The BCG vaccine provides protection against tuberculosis.

b. Brucellosis

Definition

Brucellosis, also known as Malta fever, melitococcal disease, undulant fever, or sweat fever, is an infectious and transmissible disease that affects a large number of animal species, including humans. It is caused by bacteria, the most well-known of which are:

- *Brucella abortus*, associated with bovine brucellosis;

- *Brucella melitensis*, associated with brucellosis of small ruminants;
- *Brucella suis*, associated with swine brucellosis.

All three strains are capable of causing disease in humans. The presence of *Brucella* sp is not unusual, so vigilance is necessary. Brucellosis in animals results in a reproductive tract infection, causing abortion, particularly during the final third of gestation.

Mode of transmission

Infection in humans occurs following the consumption of contaminated dairy or meat products, or through contact with infected animals.

Symptoms in humans

In humans, clinical symptoms include headache, muscle pain, sweating accompanied by a fever that can reach 40°C (104°F), and the risk of miscarriage.

c. Q fever

Definition

It is a microorganism, *Coxiella burnetti*, that causes Q fever. It is found in cows, sheep, and goats.

Mode of transmission

The infectious agent is spread primarily by breathing contaminated particles, contact with abortion fluids, and can also be transmitted through unpasteurized milk from sick animals. It is eliminated by pasteurizing the milk at 63°C for half an hour.

Symptoms in humans

In humans, *Coxiella burnetti* causes clinical symptoms similar to those of the flu (fever, headache, sweating, muscle and joint pain, nausea and vomiting, diarrhea, etc.). In animals, clinical symptoms are barely visible. This disease causes abortions and fatal births in both humans and animals.

d. Mastitis

Definition

Mastitis is an infection that affects the mammary gland. Microbes commonly associated with these infections include *Streptococcus agalactiae*, *Streptococcus dysgalactiae*, *Streptococcus uberis*, as well as coliform bacteria (*E. coli* or *Salmonella* sp.), among others.

There are two categories of mastitis:

- Overt mastitis. This is mastitis that the farmer can identify through visible changes in the animal's physical condition: inflammation of the mammary gland, development of hot, large, and painful udder sections, possibly with injuries, in addition to a decrease in appetite;
- Subclinical mastitis. The animal shows no observable symptoms, making it more difficult for the farmer to identify. However, the milk is contaminated with bacteria.

Basic milk analyses help farmers identify sick animals and remove poor-quality milk from the consumption or sale chain (mastitis test).

Many losses in the milk production chain are due to mastitis. Farmers primarily encounter problems of deteriorating animal health and interrupted milking. Mastitis causes financial harm to farmers: the organoleptic quality of the milk (color, consistency) can change, rendering it unsaleable. Also noteworthy is desquamation of the udder mucosa, with the potential for the formation of lesions on the mammary gland, which can lead to milking interruptions.

Mastitis plays a significant role in increasing the number of somatic cells and microbial flora, while also altering the chemical and biochemical composition of milk. All of these fluctuations disrupt the fermentation process during milk conversion.

There are a multitude of germs that cause mastitis, with special mention for staphylococci, the most notorious of which is *Staphylococcus aureus*. Once introduced into milk, this contaminant can generate a toxin responsible for foodborne illnesses in the consumer. Therefore, it is essential to adopt all precautionary measures to prevent the multiplication of the germ and the production of the toxin.

Mode of transmission

Usually, bacteria enter the teat canal during lactation or the dry period. Germs in the mammary gland are not the only factor contributing to the development of mastitis. This presence may be linked to unfavorable housing conditions, trauma to the udders during milking, the animal's age, or even the feed. Some animals are more susceptible to the disease, and farmers can also reduce its impact by immediately removing sick animals (especially small ruminants).

Symptoms in humans

Staphylococcus aureus in milk is not inherently pathogenic to humans. It is a bacterium found in the environment. However, it produces a toxin that can make consuming contaminated food dangerous. Ingestion of the toxin causes nausea, vomiting, diarrhea, abdominal cramps, and pain, which can last from one to several days.

Mastitis detection

Various tests can be performed on the udder or milk to identify the presence of mastitis. Among the most common are:

– Udder examination: a hard, warm, painful, or enlarged udder should suggest mastitis;

– The mastitis test or CMT11 (California Mastitis Test);

– Milk pH measurement (test paper).

III.7.3.3.2. Infectious agents present in the environment or raw materials

Pathogens are found in the environment, particularly in animal feces, as well as in the milk processing facility. As soon as they detect favorable conditions in food, their multiplication can make consumption of that food risky.

Some microorganisms may exist in the environment without reproducing if the conditions are not conducive to their growth. When these conditions change (favorable temperature and pH, presence of a nutrient medium), microorganisms reproduce rapidly. This is when the danger arises:

- Ambient temperature, between 25 and 40°C, is particularly favorable for their development;

- Milk, a particularly nutrient medium, favors their proliferation.

Conversely:

- A low temperature (4°C recommended for raw and pasteurized milk and 6-8°C for fermented milk) is less favorable to their development;
- High acidity is also rather unfavorable. This is why yogurt is less susceptible to bacterial growth than raw milk.

a. *Staphylococcus aureus*

Germ characteristics

Staphylococcus aureus is a microbe naturally present in the mammary gland. It is not considered a pathogen, but rather a hygiene indicator. It thrives in a temperature range of 6 to 48°C, with an ideal temperature around 37°C. This bacterium thrives ideally in a pH range of 5 to 7.5; however, it can survive up to a pH of 9.8.

In ruminants, infections can lead to subclinical and sometimes clinical mastitis, leading to significant contamination of milk by *Staphylococcus* sp.

Staphylococcus aureus is also found in animals, specifically in wounds, fissures, cracks, whitlows, and respiratory infections. Human forms are particularly virulent in humans. It is therefore crucial to prevent food from being contaminated by microbes of human origin.

Toxin production conditions

Under the right conditions, some varieties can produce toxins. Only the toxins can pose a threat to human health. The food retains its original taste and odor without any alteration. Pasteurization cannot eliminate the toxins produced by the bacteria.

The toxin is a heat-resistant protein that cannot be eliminated by pasteurization. To denature enterotoxin A, in vitro exposure of 3 hours at 100°C and 10 to 40 minutes at 120°C is required.

They are also resistant to digestive enzymes and stomach acid. Several conditions are necessary for its production:

- Presence of a toxin-producing strain, e.g., *Staphylococcus aureus*;
- High bacterial count (106 to 109 per ml);

- Bacteria at the end of their growth phase;
- Absence of antagonistic flora, such as lactic acid flora;
- Reduced water activity.

Symptoms in humans

Suppurative diseases are caused by the infiltration of staphylococci into the body through wounds, the urinary tract, and other sources. Food poisoning due to toxin ingestion manifests as nausea, vomiting, diarrhea, abdominal cramps, and pain that can last from one to several days. The incubation period can range from 1 to 7 hours following toxin ingestion. When the toxin is consumed, the individual becomes debilitated. The toxin can cause death in an already vulnerable individual.

Sources of contamination

Milk contamination can come from animals suffering from clinical and subclinical mastitis, the skin or teat canal, unclean hands or injuries on the milker's body, as well as equipment (rags, processing tools that retain flora even after cleaning, such as wooden tools).

b. *Salmonella* sp.

Germ Characteristics

Salmonella sp. are harmful microorganisms that cause salmonellosis in humans and animals. All species can cause disease, but infection only occurs if a sufficient number of bacteria are ingested (with the exception of *Salmonella typhi*, which causes typhoid fever).

They thrive in a temperature range of 8 to 47°C, with an optimal temperature between 35 and 36°C. They reproduce in a pH range of 4.3 to 9. Ruminants infected with salmonellosis typically experience enteritis, sometimes accompanied by hemorrhages, as well as various respiratory problems, potential abortions, or septicemia. Treatments rely on the use of antibiotics and anti-inflammatory drugs.

Symptoms in humans

Salmonellosis generally manifests as abdominal pain, diarrhea, vomiting, and fever. In the most serious cases, septicemia can occur, as well as meningitis, pericarditis, and

endocarditis. Symptoms appear between 7 and 72 hours after consumption of the product. These conditions are extremely serious and can lead to death in vulnerable individuals (children, the elderly, people with weakened immune systems, etc.).

More susceptible individuals develop salmonellosis with lower bacterial doses than healthy people. Typhoid fever is caused by the bacterium *Salmonella typhi*. It differs from other forms of salmonellosis in that a single ingested bacterium can cause illness.

It is characterized by a high fever, accompanied by ulceration of the small intestine. This disease is fatal; however, an effective vaccination for humans is available. The incubation period lasts from 7 to 21 days. Individuals with typhoid fever continue to shed the bacteria in their feces for several months. Therefore, monitoring for typhoid fever is particularly important for employees working in milk processing units.

Sources of contamination

Infection on farms is primarily caused by excreting animals, whether sick or healthy (cattle, sheep, goats, dogs, rodents, poultry, pigeons, etc.), humans, and contaminated water and feed. Environmental pollution from animals is not solely the result of sick animals. Once recovered, these animals release large quantities of *Salmonella* through their feces or droppings for several years.

It is common to encounter animals with contaminated feces, despite the absence of a clinical history of salmonellosis in the individual or herd.

- The animal: cows, monkeys, poultry, and pigs can contaminate milk through their feces if they are sick or healthy carriers.
- The farm: Milk can be contaminated through the milker's soiled hands, borehole water, well water, or milking equipment (filter screens, cans).
- The dairy: Staff hands can be potential sources of contamination if these workers are sick or healthy carriers. Improperly disinfected equipment (e.g., equipment used for homogenization and mixing: ladles, whisks, and wooden utensils) is also a source of contamination, as is yogurt used as a starter culture.

c. *Escherichia coli*

Germ characteristics

Escherichia coli is a fecal coliform bacillus that belongs to the *Enterobacteriaceae* family. It is a microbe normally found in the digestive system of living organisms. It is not very demanding nutritionally and grows anywhere where survival conditions are favorable (warmth and humidity). Only certain strains are pathogenic.

E. coli can reproduce between 8 and 47°C, with an ideal temperature of 30 to 40°C. The ideal pH range for its multiplication is between 4.3 and 9.

In ruminants, *E. coli* infection manifests itself in a variety of clinical forms. Mastitis caused by *E. coli* is primarily clinical in nature (presenting clearly observable symptoms), but it can occasionally (less frequently). The infected animal does not show any clinical symptoms. Therapies are based on the use of antibiotics.

Symptoms in humans

There is one strain of this microbe that is particularly virulent: the O157 H7 strain, known in particular for causing bloody diarrhea. Symptoms generally include diarrhea and nausea, often accompanied by vomiting.

"Tourista" is caused by a variant of *E. coli* that is very rarely fatal. Diarrhea is generally the main manifestation of *E. coli* infections. Specific strains cause hemolytic-uremic syndrome in children, leading to severe kidney failure. Some strains can cause severe symptoms in adults (fever, bloody diarrhea, dehydration).

Sources of contamination

- Living beings and their environment: *E. coli* bacteria are normally found in the digestive system and, consequently, in the feces of animals, including humans. This route is responsible for the contamination of bedding and water. In livestock farming, contaminated bedding, water, and surfaces are frequently conducive to the persistence and growth of this microbe.
- In milking, the milker's hand, poorly cleaned udders, and the cow's movements (leg and tail stroking) can contaminate the milk. Milking equipment can also be a source of contamination. Any digestive disorder in an animal causes fecal elimination and the resulting risk of milk contamination.

- In the dairy industry, contaminated water, impure ferments and starter cultures, unclean hands, and insufficiently disinfected equipment are sources of pollution. It is important to monitor the quality of the water, especially that used for reconstituting milk when using milk powder. In addition to microbiological quality, it may be beneficial to keep an eye out for certain parasitic diseases: balantidiasis, amoebic dysentery, toxoplasmosis, ascariasis, and pinworm. It is important to note that pasteurization generally eliminates *E. coli*.

III.7.3.3.3. Animal feed hazards

Like many other agricultural commodities (cereals, dried fruits, etc.), peanuts can provide a favorable environment for the development of saprophytic fungi, some of which produce mycotoxins or substances harmful to human health. Aflatoxins, produced by *Aspergillus flavus* and *parasiticus*, are one of the metabolites that frequently affect peanuts grown and processed under unsuitable conditions.

These toxins possess carcinogenic (liver) and mutagenic properties. They may also increase the risk of developing kwashiorkor disease in children. These heat-stable compounds are removed during oil refining through ammonia treatment. They also react with most heat processes applied to milk, such as sterilization and pasteurization.

Manual oil production does not allow for this removal, and the residues may therefore contain aflatoxins. Thus, milk from a cow fed this meal may also contain them. It would be preferable to favor industrial meals, which pose fewer risks. Another danger lies in improper food preservation, which can promote the growth of fungi such as yeasts and molds.

Furthermore, the ingestion by animals of fodder and water polluted with heavy metals can pose health problems when consuming milk. Consuming large amounts of foods rich in phytoestrogens (such as soy) can also pose a risk.

III.7.3.3.4. Transport hazards

The transport of milk from farms to dairy plants often takes place under conditions conducive to the proliferation of microorganisms:

- Milk containers (cans) often have narrow openings, making them difficult to use;
- Transport times can sometimes be prolonged (time between milk collection and

pasteurization exceeding 4 hours);

- Several types of milk from different sources may be combined;
- The outside T°C is often high (it can even exceed 40°C), which favors the growth of bacteria.

III.7.3.3.5. Hazards associated with pathogenic bacteria from personnel

There are medical conditions that make the handling of milk and dairy products incompatible. Individuals with whitlows or infected wounds act as reservoirs and carriers of harmful bacteria. Thus, they have the ability to spread these infectious agents through contact with the products. Therefore, wounds must be disinfected and protected.

Individuals with infectious diseases of the skin, digestive system, or respiratory system can contaminate food through their handling. Some people may also be carriers of germs without showing symptoms of illness. These are referred to as healthy carriers. In this context, without strict adherence to basic hygiene measures, the risk of contaminating food or equipment becomes significant.

Certain actions (such as blowing your nose or scratching) during handling can transmit germs to the milk. The risk of contamination by operators (via their hands, clothing, etc.) poses a threat. Indeed, failure to comply with hygiene standards and insufficient personal hygiene in both the dairy and the barns have a significant impact on the microbiological quality of the milk.

III.7.3.4. Physical hazards: presence of debris in products

The use of certain products or equipment can cause unwanted contaminants in milk and milk products. Wooden spatulas and whisks (with wooden handles) are used in milk processing units to homogenize and mix milk.

If milking methods are not optimal and the milk is not properly filtered, residues such as wood shavings, grains of sand, hair, etc., may end up in the milk or its products.

If the sugar used in the processing is not of good quality, it may also contain various residues and impurities, which can even dull the color of the yogurt. The presence of residues in milk can affect not only the quality of the product, but also the consumer's mood.

III.7.3.5. Other hazards

III.7.3.5.1. Technological hazards

These types of risks must be monitored within cheese factories. Indeed, milk processing is a series of technical processes that require extensive expertise to produce products that are safe for the consumer. Possible sources include:

- Lack of mastery of pasteurization: inconsistent time-temperature ratios;
- Cultures: contamination by poor-quality yogurt or curds during inoculation, lack of control over the quantity required for inoculation;
- Packaging: possibility of contamination by personnel following handling without specific hygienic precautions (wearing jewelry, blowing into bags);
- Storage of products in the unit or in sales channels at temperatures exceeding 4 to 5°C;
- Excessive time between purchase and consumption of the product, thus breaking the cold chain, which can contribute to its deterioration. It can cause health problems for the consumer and tarnish the image of the product, which appears to be of poor quality.

III.7.3.5.2. Presence of colostrum

After calving, the cow should not be treated for a period of 5 to 7 days for human consumption. Indeed, she produces colostrum on the first day, followed by transitional milk, the composition of which gradually tends to approach that of whole milk.

III.7.3.5.3. Water quality

It is important to monitor water quality, especially that used to reconstitute milk when using milk powder. In addition to microbiological quality, it may be beneficial to monitor for certain parasitic infections: balantidiasis, amoebic dysentery, toxoplasmosis, ascariasis, and pinworm.

Chapter IV: Risk management

IV.1. Introduction

In many human activities (chemical industry, petrochemicals, agriculture, metallurgy, etc.), chemical risks are constantly present and can cause harmful effects for humans and the

ecosystem. Chemical risks arise from the use, handling, or storage of chemical substances.

Directive 98/24 defines them as "the probability that the potential harm will be reached under the conditions of use and/or exposure."

Chemical risks, associated with product characteristics, result in acute injuries such as burns, irritations, poisoning, etc., or long-term chronic effects that can lead to diseases (such as cancer, etc.). The physicochemical characteristics (flammability, explosiveness, toxicity, hazardous reactions) of the substances we use, handle, or store highlight the danger posed by their exposure as a potential source of chemical risk.

Large-scale industrial accidents occurring in facilities for the production, storage, and transportation of hazardous materials (HDM) also originate from chemical risks. We take this opportunity to recall the major accidents that marked the end of the last century: the SEVESO ecological disaster in 1976 (an explosion resulting in a massive release of dioxin and the death of more than 70,000 animals); the Bhopal accident in 1984 (an explosion releasing methyl isocyanate, causing more than 3,000 deaths); the AZF explosion in Toulouse in 2001 (due to the storage of NH_4NO_3, resulting in 27 deaths); and finally that of Skikda in 2004 (explosion of an LNG tank which caused 23 victims). In the industrial sector, the presence of chemical substances increases the severity of accidents in the event of failure of the installations.

IV.2. Classification of chemical risks

There are two main categories of chemical risks: poisoning risk and fire-explosion risk. The following table summarizes all chemical risks.

Table 2: Chemical risks

Poisonings	Accidental poisonings
	Occupational pathologies
	Occupational diseases
Dangerous chemical reactions	Toxic substances
	Flammable and toxic substances
	Flammable substances
Fires and explosions	Fires
	Explosions

VI.2.1. Risk of poisoning

Any substance, whether pure or mixed, that enters the human body by any means can potentially disrupt or even alter the body's normal functioning. The ingested product preferentially binds to one or more organs in the body; this leads to more or less significant dysfunction, manifesting itself in the emergence of diseases.

Depending on various factors, including the nature and reactivity of the chemical absorbed, poisoning can manifest in two distinct ways: accidental or chronic. Accidental poisoning occurs when a highly toxic substance is absorbed or comes into contact with the body in large quantities. The chemical acts quickly (within minutes) at the point of contact in the body, causing cell destruction.

Chemical burns due to the projection of concentrated acids and bases, the inhalation of aggressive or asphyxiating gases and vapors (chlorine, sulfur dioxide, nitrous vapors, peroxides), as well as the absorption of highly toxic substances (inhalation or oral ingestion of hydrocyanic gas, hydrogen sulfide, phosgene, etc.) constitute accidental poisonings whose severity varies depending on the quantities involved. In the professional context, accidental poisoning is classified as an accident at work and compensated accordingly.

Chronic poisoning results from the regular ingestion of small doses of toxic substances over varying periods of time. Various illnesses, the most common of which are occupational diseases, are the result of chronic exposure to toxic substances. Generally, these substances are chemically unreactive, but they can react in a biological environment.

The same product can develop, depending on the case and the quantities absorbed:

- Accidental poisoning (sudden onset through skin contact) or absorption (orally and through the respiratory tract) of large quantities of toxic substances;
- An occupational illness or disease after several days, months, or years of daily ingestion of small amounts of toxic or harmful substances.

Consequently, skin exposure to hydrofluoric acid, formalin, or chromic acid can lead to accidental chemical burns, as well as occupational illnesses. The absorption of small doses of these elements by the body over short or prolonged periods leads to well-known occupational diseases (asthma, cancer, pulmonary edema, skin and nasal ulcers).

IV.2.1.1. Poisoning process

Depending on their characteristics, the way they enter the body, the amount absorbed, and the individual, hazardous chemicals can cause varying degrees of health damage. The routes of entry of a hazardous product into the human body are directly related to the product's physical state. The human body essentially has three routes of entry for chemicals.

IV.2.1.1.1. The digestive tract

The absorption of chemicals through the digestive tract can take two forms:

- An accidental form through the ingestion of a large quantity of the product;
- A chronic form through the repeated ingestion of low doses.

IV.2.1.1.2. The respiratory tract

Airborne particles in a workplace consist mainly of dust, vapors, and fumes. These particles, which can have a variety of effects on the lungs and other organs of the body, therefore place the respiratory tract at particular risk. A resting adult inhales approximately 45 liters of air every minute. During intense activity, they breathe in more than 20 liters.

Large dust particles (0.1 to 0.01 mm) are captured by the upper respiratory tract, while smaller particles (0.005 mm or less) easily reach the pulmonary alveoli. Vapors and fumes penetrate the lung membrane and enter the bloodstream. Some of these substances can cause varying degrees of damage to the respiratory mucous membranes (as in the case of sulfuric acid vapors, for example).

IV.2.1.1.3. The cutaneous route

The skin provides excellent protection, but it is exposed to many attacks. Problems can arise when items come into contact with it. Some people experience irritation, others cause tissue destruction, and some penetrate the barrier that is our skin.

VI.2.2. Fire-explosion risk

Many chemicals and various materials, classified as combustible (or flammable), combine with oxygen in exothermic reactions, i.e., reactions producing considerable amounts of heat. These are oxidation or combustion reactions that require the presence of free (atmosphere) or combined (oxidants) oxygen.

These reactions release intense heat, which heats the material. In this context, several scenarios can occur. The combustion reaction produces heat that decomposes substances into gases and/or vapors, whether flammable or not, as well as highly reactive free radicals. Thus, a chain reaction begins and the fire spreads as long as flammable gases continue to form. Several scenarios can occur:

- If the reaction is very slow, the heating is not noticeable. This is not truly combustion, but simple oxidation, like many metals in the air such as iron, copper, and zinc. This is not combustion, but simply oxidation;
- If the combustion rate is high, the heating is significant and the decomposition releases gases that can ignite;
- When the combustion rate is very high, the amount of heat released is very high, and the gases formed exert high pressure, which in a confined space causes an explosion;
- In the absence of gas formed, the heat released keeps the product at a high temperature, causing incandescence until combustion stops due to lack of fuel.

IV.2.3. Risks due to hazardous chemical reactions

Many chemical reactions are classified as "hazardous" because they result in the creation of toxic, flammable, or otherwise hazardous substances. This primarily concerns rapid and uncontrolled reactions resulting from accidental contact between so-called "incompatible" substances. These reactions can occur either as side reactions during poorly controlled syntheses, as unpredictable agglomerations (following leaks, for example) of incompatible substances, or as spontaneous reactions involving unstable or explosive products.

The main risk of these hazardous reactions is the formation and release of:

- Toxic substances (hydrocyanic acid, chlorine oxides, nitrous vapors);
- Flammable substances (acetylene, hydrogen);
- Substances that are both toxic and flammable (hydrogen sulfide, ammonia).

Due to their unpredictable nature, these dangerous reactions are the cause of many serious accidents (explosions, liquid projections, gas emissions). Most industrial accidents occurring in factories are caused by such reactions.

Hazards associated with hazardous chemical reactions are ubiquitous; they are

particularly significant during the preservation of chemical products (storage areas and warehouses) and in certain operations requiring the use of a wide range of substances, such as finishing operations, heat treatments, workshops handling laminated composites, etc. The risk of fire and explosion arises from hazardous chemical reactions, including combustion.

IV.3. Main parameters affecting chemical risks

Several factors influence the attributes of chemical risk; the likelihood of an incident or illness occurring is linked to these same factors, and controlling them facilitates risk management and the implementation of preventive measures. The main factors are:

IV.3.1. Chemical nature of the products in question

It is the composition and molecular structure that define the characteristics of the products. Chemical products do not all possess the same attributes, and therefore their hazards vary; non-flammable substances are unlikely to cause fires or explosions, and the illnesses caused vary depending on the organ affected by the ingested substance; many organic solvents are both hazardous and combustible.

The more reactive a product is, the more dangerous it is. The molecular structure of substances plays an important role in this reactivity.

IV.3.2. Physical state

The appearance of the product has a significant impact on the chemical risk. Substances in gaseous or highly fragmented form (dust, fumes, mists) represent the greatest hazard. Therefore, silica (silica sand a few millimeters in diameter) is not toxic; However, in the form of fine dust that enters the body through the respiratory tract, it causes a fatal occupational disease called silicosis.

An iron nail will not ignite in air at room temperature; however, extremely fine iron powder can spontaneously combust. As a general rule, the more fragmented a substance is, closer to the molecular state, the more dangerous it is. According to this principle:

- Gases and vapors penetrate the body more easily than liquids and solids. Likewise, they mix more readily with air to produce dangerous combustion reactions;
- Solids in a powdered state penetrate the body more easily because they are stably suspended

in air to form aerosols. This is the case with highly toxic silica dust;

- Vapor formation increases with the volatility of the product; the more volatile a substance, the greater the vapor quantities. The lower the boiling point, the more volatile the product. Generally speaking, the use of heavy solvents with high boiling points.

IV.3.3. Absorbed quantities

Increasing the volume of toxic substances ingested by the body increases the risk of poisoning. Substances that, when ingested daily in small quantities, cause occupational illnesses can cause accidental poisoning if present in large quantities. This applies to many solvents, amines, and formaldehyde.

IV.3.4. Temperature

Generally speaking, increasing temperature increases the hazardous nature of the product.

IV.4. Product management: hazard identification: labeling and safety data sheets

The presence of chemical hazards is indicated on the products in question through labels and safety data sheets. European directives are at the origin of the concept of safety data sheets, as is the concept of notifying new products to authorized bodies.

IV.4.1. Knowledge of chemical products

To implement safety measures when using chemicals, it is essential to understand all the elements that define them, which are as follows:

- The chemicals present, even in trace amounts, and particularly hazardous products;
- The processes and reaction mechanisms involved, including side reactions;
- The facilities and their equipment that enable the various operations necessary for the planned production.

It is important to ensure that all information regarding the risks associated with existing chemicals in the workplace is communicated to employees:

- Create an inventory list of chemicals;
- All chemicals must be listed in the product inventory list;
- Each existing chemical must have its own Material Safety Data Sheet (MSDS).

IV.4.2. Material safety data sheet (MSDS)

According to the French Labor Code, manufacturers, importers, and retailers are required to provide users (company managers and employees) with safety data sheets, which must be submitted to the organization's occupational health physician.

These sheets contain a variety of information and guidelines, including specific details on the hazards associated with products under various conditions of use, safety and prevention measures to be adopted, firefighting, first aid in the event of an incident, ecotoxicity, as well as details regarding transportation, storage, and waste management.

These sheets, commonly referred to as safety data sheets, will be kept by the company and made available to various regulatory or advisory bodies. The information contained on these safety data sheets is grouped into 16 sections:

1. Identification of the chemical product (trade name, declaration number, classification, nature of the packaging) and the identification of the natural or legal person responsible for placing it on the market;

2. Information on the components (composition of the product, highlighting in particular the presence of hazardous products and their characteristics);

3. Hazard identification (for workers and the environment);

4. Description of first aid measures to be taken in case of emergency (following an accident or incident);

5. Fire-fighting measures (fighting rules, fire extinguishers, formation of toxic gases);

6. Measures to be taken in case of accidental release (leaks, splashes, emissions of gases and vapors, environmental protection, clean-up of the scene after the accident);

7. Precautions for storage, use, and handling;

8. Procedures for controlling worker exposure and characteristics of personal protective equipment (monitoring procedure, personal protection);

9. Physicochemical properties (appearance, odor, pH, density, solubility, etc.);

10. Product stability and reactivity (reaction with heat, with water, etc.);

11. Toxicological information (dangerous health effects and possible symptoms, immediate or chronic effects);

12. Ecotoxicological information (degradability, bioaccumulation, effects on flora and fauna);

13. Information on waste disposal options (incineration, recycling, landfill).

14. Transport information;

15. Regulatory information;

16. Other information.

The SDS sheets for the products used must be accessible to all employees and must contain the following information:

- Name of the manufacturer or distributor and emergency telephone number;
- Physical and chemical properties of the product;
- Physical and chemical hazard;
- Signs and symptoms of exposure;
- Emergency first aid procedure;
- Flammability and explosion hazard data;
- Extinguishing procedure;
- Spill cleanup precautions;
- Control methods or exposure limits;
- Whether the substance can cause cancer;
- The name of the person who prepared the safety data sheet and the date of preparation or revision.

IV.4.3. Labeling of packaging and containers

Safety data sheets, intended for company managers, occupational physicians, and supervisors, provide crucial information for implementing preventive measures related to chemical risks. Furthermore, the label, which is affixed directly to the packaging, provides the user with essential information to alert them to hazards and the precautions to be taken when handling hazardous products.

Thus, all items used in the workplace that meet the standards to be considered hazardous must bear an appropriate label. Labels are the first indicators for the user of the major risks associated with the product, and they explain the essential precautionary measures and safety precautions to be adopted.

IV.4.3.1. Labeling of hazardous substances

Nine annexes define the rules relating to the packaging and labeling of hazardous substances. The packaging must be sufficiently robust and leak-proof to prevent product loss through leakage, even after repeated opening and closing; it must also be protected from substances that could damage it (for example, do not place hydrofluoric acid in glass packaging).

Any packaging containing a hazardous material must bear a label (or possibly a notice for small packages) that is clearly visible and easy to read, securely attached to its backing (usually adhesive), and appropriate for the packaging's dimensions.

In accordance with the imposed conditions, all substances and preparations must bear a label. A product not mentioned on this list is not necessarily safe; there are still a multitude of recent products, substances, or mixtures containing hazardous components that are not included, either because they are new or because their exact toxic properties are not yet established. It is therefore the responsibility of the manufacturer or distributor to take appropriate measures when declaring the product to the authorized entities.

Since the information on the label must always be accessible to direct users, it is necessary that labels or inscriptions also be present on divisional packaging (products delivered in large quantities and repackaged in smaller, practical containers for daily or weekly use) (figure 25).

The supplier label must include the following information:

- **Product identifier –** brand name, chemical name, common name, generic name, or trade name of the hazardous product;
- **First supplier identifier –** the manufacturer's name, address, and telephone number;
- **Pictogram(s) –** hazard symbol enclosed in a red border;
- **Signal word –** term or phrase used to inform the reader of a potential hazard and to indicate the severity of that hazard;
- **Hazard statement(s) –** standardized phrase describing the nature of the hazard posed by a hazardous product;
- **Precautionary statement(s) –** standardized phrase describing the measures recommended

to prevent adverse effects resulting from exposure to a hazardous product.

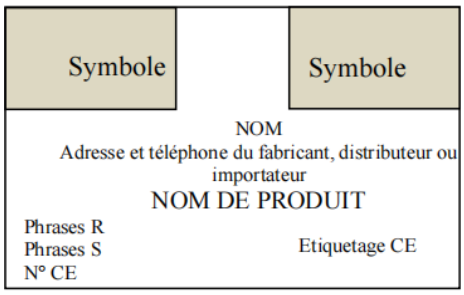


Figure 25: Label for hazardous substances

The figure 26 concerning the declaration, classification, packaging, and labeling of hazardous chemicals. Each label contains one or two symbols with hazard indications.

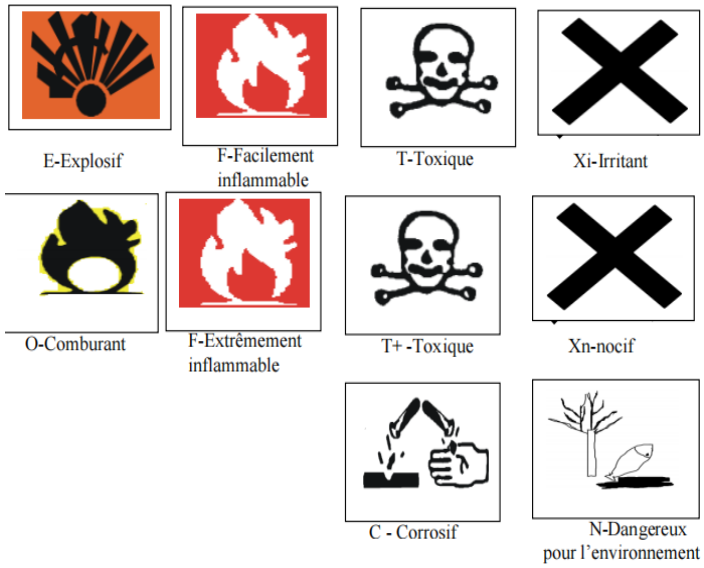


Figure 26: Symbols (pictograms) with hazard indications appearing on the labels.

IV. 4.3.2. Special labeling

Articles originating in the United States bear a specific label (NFPA Standard). The National Fire Protection Association (NFPA) developed this label to assist emergency responders in quickly identifying hazards associated with this product:

- Red: Risk of fire (figure 27)

0. Non-combustible
1. Combustible if heated
2. Caution: Combustible liquid

3. Warning: Flammable liquid

4. Danger: Flammable gas **Figure 27:** NFPA Standard

- Yellow Color: Reactivity:

1. Caution: Unstable if heated

2. Caution: Unstable, may react with water; violent chemical changes are possible

3. Danger: May explode if heated

4. Danger: May explode at normal temperature

- Blue Color: Health hazard

0. No Unusual Hazard

1. Slightly Hazardous: May cause irritation

2. Hazardous: May be harmful if inhaled or absorbed

3. Extreme Hazard: Corrosive or toxic; avoid inhalation

4. Fatal: Special equipment required

W- Avoid use of water

ALK- Base (Alkaline)

ACID- Acid/Acidic

COR- Corrosive

Radioactive Symbol = Radioactive

- White Color: Special hazard

IV.4.3.3. General labeling rules

- Labels must be securely affixed to one or more sides of the immediate packaging of the substance or mixture and must be legible horizontally when the packaging is laid down in the normal manner.

- The labeling elements themselves, particularly the hazard pictograms, must stand out clearly from the background.

- Furthermore, all labeling elements must be of sufficient size and spacing to be easily legible. They must be clearly marked.

IV.5. Waste segregation and pollution control

Waste management must be based on the selection and determination of the treatment method. The quality of the latter is determined by the former. The more rigorous the sorting, the more cost-effective waste management will be. Waste packaging will be determined based on its treatment method and its physicochemical properties.

IV.5.1. Solids

IV.5.1.1. General waste

General waste is considered to be waste that does not contain toxic, flammable, or reactive materials (cardboard, paper, etc.). This waste will be transferred to household waste landfills. If recycling is possible, some so-called "general" waste can be sorted.

Examples:

- Glass: Provided it does not contain hazardous substances and is thoroughly rinsed.
- Plastics: Bottles from forming tests can be reused to make "low-end" items.

IV.5.1.2. Special waste

Materials that have been in contact with a harmful substance or reaction products must be stored separately and then transported to an authorized destruction center. The use of airtight or ventilated bins is essential for storage in laboratories.

Example:

- Do not dispose of pyridine-inhibited filter paper in household trash.
- Containers in which waste is stored must be clearly identified.

IV.5.2. Liquids

IV.5.2.1. Water

Except for sanitary water, which may be directed to the urban sewer system, all water from laboratories must be treated at a wastewater treatment plant. This ensures that its discharge into the natural environment or into a wastewater system complies with prefectural discharge standards, departmental health regulations, or the prefectural operating order.

IV.5.2.2. Hazardous liquids

Under no circumstances should hazardous liquid residues be discharged into the wastewater drain. These include:

- Flammable liquids that are immiscible with water (benzene, ether);
- Harmful or toxic products (cyanide, sulfide, chromium);
- Corrosive products must be collected separately.

Some types of residues are collected by a network in some laboratories. A directive will be necessary to specify the type of waste that can be discharged there. Acids and bases will be neutralized to obtain solutions with a pH between 5.5 and 8.5. In this scenario, they could be discharged down the sink. It is necessary to separate chlorinated solvents from other types of solvents to prevent any hazardous reactions and simplify their subsequent treatment by incineration.

IV.5.3. Gases

When a cylinder is classified as waste, it must be returned to its owner, who assumes responsibility for it. If the gas cylinder is the property of the laboratory, it must first be emptied, purged, and rinsed, then filled with water before being punctured to render it inoperable. It is recommended to hire an expert company for cylinders that have contained corrosive or toxic gases.

IV.5.4. Reagents

To avoid accumulating a large quantity of expired or obsolete reagents (which will increase the "waste" item), it is necessary to order products in small quantities.

The management and disposal of hazardous products must be entrusted to a specialized company, ideally the product manufacturer. Until their complete disposal, the waste producer is responsible for their disposal. It is therefore essential to carefully monitor the waste's route once it leaves the company.

- Clearly specify the type of waste;
- Keep shipping slips;
- Request incineration certificates;
- Keep the waste logbook up to date.

IV.6. Chemical risk management

Controlling chemical risks on work sites (laboratories, workshops, or workstations) requires the implementation of technical, organizational, and human (THO) measures for effective management (figure 28).

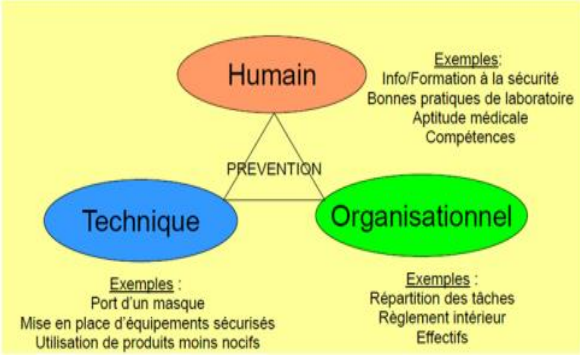


Figure 28: Three prevention methods

Whether in a laboratory or on a corporate worksite, chemical risk prevention requires a good understanding of the hazards and risky situations that could cause harm or compromise the health and safety of the exposed individual(s).

Chemical risk prevention therefore requires the implementation of various essential ongoing actions. These include:

- To reduce the impact of chemicals on the health and safety of employees in companies or students and researchers in universities;
- To initiate actions to substitute the most hazardous products;
- To rationalize the consumption of chemicals;
- To meet a legal obligation.

The Labor Code stipulates that the manager of the establishment (company, university) is responsible for the prevention of chemical risks in the workplace.

- REACH

Since its entry into force in June 2007, the European REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals) regulation has aimed to strengthen measures for identifying risks associated with chemical substances for humans and the environment. This refers to any substance intended for public consumption whose production exceeds one ton per year. Any company marketing chemicals in large quantities is required to assess their impact on health and the environment upfront. Consequently, the manufacturer must conduct a risk assessment, minimize them, and provide safety instructions.

- SEVESO 3 directive

The Seveso 3 Directive, which concerns major accidents involving dangerous substances, has been in force since June 1, 2015, and succeeds Directive 96/82/EC, known as "Seveso 2." Since June 1, 2015, new obligations have been introduced for establishments to prevent and more effectively manage major accidents involving dangerous chemical substances.

The following actions must be implemented:

- Chemical classification:

- Hazard testing and characterization and classification of chemicals;
- Health and environment;
- Exemption application.

- Classification of your establishment:

- ICPE and SEVESO classification, accumulation rules, 2% rule;
- Optimization of quantities present to maintain your current classification;
- Response to new regulatory constraints for all types of activities:
    - EDD: Identify hazardous products and substances. Develop and assess hazard studies;
    - SMS: Evaluate and implement your Safety Management System;
    - Development of emergency plans (POI/PPI): Evaluate and develop your Internal Operations Plan (establishment manager) / Specific Intervention Plan (Wali).

IV.7. General principles of risk prevention

Prevention is an action to reduce the frequency of risks. It is an attitude or a set of measures to be taken to reduce or even eliminate risks. According to the French Labor Code, Article L. 4121-2 describes nine general principles that govern the organization of prevention:

Avoiding risks means eliminating danger or exposure to danger;

Assessing risks means assessing exposure to danger and the significance of the risk in order to prioritize prevention actions;

Combating risks at the source means integrating prevention as early as possible, particularly in the design of workplaces, equipment, or operating procedures;

Adapting work to individuals, taking into account inter-individual differences, with the aim of reducing the effects of work on health;

Taking into account technological developments means adapting prevention to technical and organizational developments;

Replacing what is dangerous with what is less dangerous means avoiding the use of dangerous processes or products when the same result can be achieved with a method presenting less danger;

Planning prevention by integrating technology, organization and working conditions, social relations, and the environment;

Prioritizing collective protection measures and only using personal protective equipment to supplement collective protection if it proves insufficient;

Providing appropriate instructions to employees means training and informing employees so that they are aware of risks and preventive measures. This involves:

- Information and training on risks and hygiene measures;
- Access to safety data sheets;
- Training on safe working methods;
- Training in the use of PPE;
- Writing and posting job descriptions.

IV.8. Hazard control

IV.8.1. Pay attention to dairy animal feeding

Milk production is affected by the quality and quantity of feed. Feeding poses many risks. Indeed, feed can contain various residues and contaminants such as mycotoxins, pesticides, heavy metals, phytoestrogens, and so on.

IV.8.1.1. Control methods

It is imperative that farmers refrain from allowing animals to graze in areas with a high risk of contamination and that they control feed and drinking water sources to avoid any contamination of feed by contaminated soil. Indeed, the excessive use of pesticides poses a real threat of contaminating pastures and agricultural residues.

The discharge of industrial and mining waste into the environment also poses a threat. It is also essential that farmers monitor excessive consumption of legumes rich in phytoestrogens.

IV.8.2. Pay attention to herd health

The health of the animal has an impact on the quality and volume of milk produced. The main threats are related to diseases such as tuberculosis or brucellosis, due to the fact that microorganisms can be transmitted through milk. Mastitis, whether clinical or subclinical, can also cause milk contamination.

Furthermore, following antibiotic treatment of animals, residues may remain in the milk. This has negative repercussions for processors, as the milk does not coagulate, and also raises public health concerns (the ingestion of small doses of antibiotics by consumers can encourage the development of resistant bacteria).

IV.8.2.1. Control methods

Whenever possible, farmers will conduct annual checks on all animals in the herd and each time a new animal is added. In all cases, farmers may contact the competent authorities in the collection area to gain a better understanding of the application of these provisions.

Clinical mastitis can be identified by observing the animal. Whenever possible, we will endeavor to remove milk from diseased animals (swollen udder quarters, injuries, etc.) from production and consumption.

To identify subclinical mastitis, farmers may perform basic examinations themselves (such as mastitis testing). As part of optimal herd management, it would be wise to systematically discard animals affected by brucellosis and tuberculosis, and gradually discard those suffering from chronic mastitis.

When acquiring new animals, it is essential to ensure they are free of these diseases before adding them to the farm. It is also crucial to comply with regulations regarding the authorization of veterinary product use and waiting periods before milking animals, both for their well-being and the quality of the milk they produce.

The aforementioned measures must be adopted at the farm level. Where possible,

processors should strive to raise awareness of these animal health issues among the farmers whose milk they purchase. By conducting unit-level tests, they will guide farmers, particularly those who are most concerned about the quality of their milk. This process of consulting and selecting producers also offers processors the opportunity to improve their economic performance. However, whatever the situation, even if the processor attaches great importance to the quality of the milk supplied by dairy farmers, he must not consider his herd as free from brucellosis and tuberculosis; he must apply systematic pasteurization of the milk.

IV.8.2.1.1. Tuberculosis and Brucellosis

- Regular screening of animals is recommended, particularly if they come from another herd.
- It is imperative to systematically pasteurize milk before consumption or use for processing. This is a safety feature for dairy processors, covering all eventualities if the farmer's control is not perfectly controlled. Indeed, pasteurization can eliminate the bacteria, but it requires strict adherence to the required time-temperature protocol.
- Before performing certain procedures (such as delivery or examination of the placenta), individuals working with infected herds are recommended to wear boots and gloves.

IV.8.2.1.2. Mastitis

- Detect, prevent, and treat mastitis;
- Whenever possible, prioritize keeping unaffected animals.

Milking Mastitis

- Strictly observe milking hygiene;
- Wash the udders;
- Dry the udders with a clean cloth;
- Systematically treat mastitis under the guidance of specialists.

Environmental Mastitis

- Provide good ventilation in the barns;
- Change the bedding frequently;

- Scrape and clean the holding area after each milking;
- After milking, keep the cow standing if possible to prevent her from lying on the contaminated ground: this position should be maintained for half an hour, until the teat sphincter closes;
- Perform regular mastitis tests to identify affected animals.

IV.8.2.1.3. Infectious agents in the environment

To prevent contamination, it is essential to implement strict hygiene measures:
- Follow hygiene standards within livestock facilities (ventilation, daily cleaning to keep animals clean);
- Respect milking hygiene;
- It is essential to regularly clean and disinfect all equipment in contact with milk;
- Control rodents, birds, and insects that can carry these bacteria;
- Ensure the health and hygiene of personnel.

To prevent the proliferation of microorganisms in processed products, adequate lactic acidification must be implemented and, above all, rigorous control of the cold chain must be ensured (temperature not exceeding 4 or 8°C depending on the product). To reduce the risk of contamination from animal feed, it is essential to store feed away from pesticides and avoid grazing animals near treated fields. Avoid using feed and drinking water from areas at high risk of heavy metal contamination.

IV.8.3. Maintaining milking and transport hygiene

Adopting rigorous hygiene during milking is a crucial element of the control system necessary to produce safe and healthy milk and dairy products.

Contamination can occur if the cow's udders are not properly cleaned. The movement of the animal's tail can cause contamination by spreading infectious agents (feces or hair present in the milk). Certain milking methods (such as immersing hands in milk to soften the udders or poor milker cleanliness) promote an increase in the number of microorganisms present in the milk. The milking environment (dust, insects, various debris) contributes to milk pollution.

Due to its end use, raw milk must be handled, stored, and transported in a manner that prevents contamination and minimizes the increase in its microbial load as much as possible. When it comes to milk transportation, contamination risks can arise from the use of narrow-mouthed plastic containers (such as old oil drums), which are difficult to clean properly. Sometimes, farmers must travel long distances to reach the processing unit. During transportation, which can sometimes exceed 4 hours, the temperature of the milk rises, which promotes the proliferation of microorganisms.

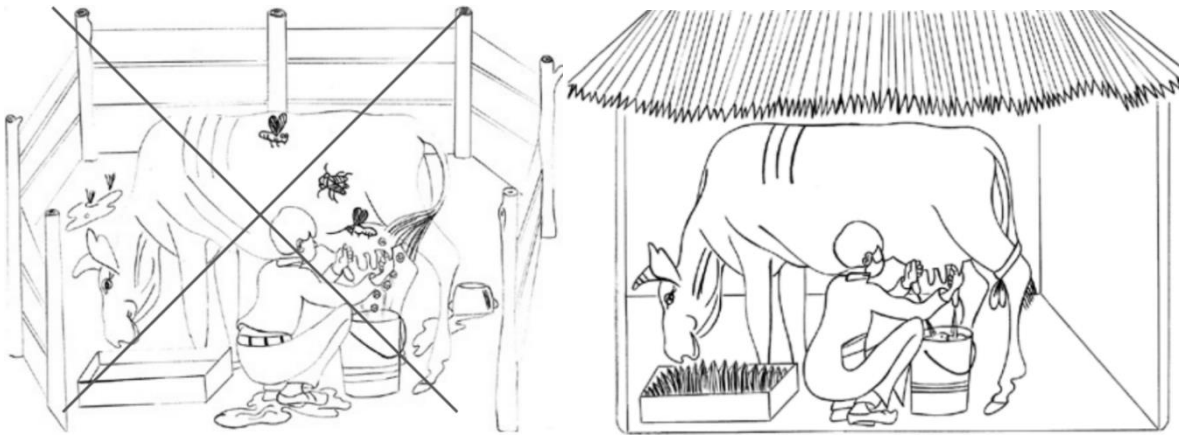
IV.8.3.1. Control methods

IV.8.3.1.1. During milking

During milking, it is imperative to scrupulously observe the milker's personal hygiene and clothing rules, the cleaning and disinfection of milking equipment (towel, bucket, cup, sieve, and funnel), and the cleanliness of the milking area.

Actions such as applying grease to the udders or dipping fingers in the milk to lubricate the teats should be avoided, as they lead to an increase in the initial bacterial load (figure 29).

- Tie the cow's tail;
- Clean and dry the udder with a clean cloth before milking;
- Check the first discharges from each teat for mastitis;
- Udders must be cleaned and dried with a clean cloth. It is suggested that the first three milk streams be removed (if there has been no prompting by the calf) before collecting the milk (figure 30).



a b

Figure 29: a: Contamination hazards in the milking area; b: Good milking practices: tail tied and clean milking air.

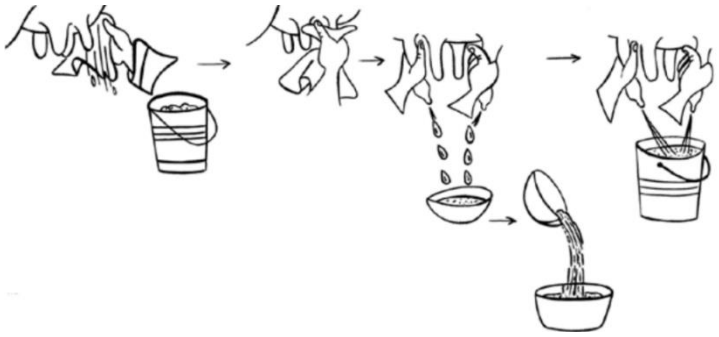


Figure 30: Milking process

IV.8.3.1.2. During milk transport

Milk must be transported quickly in wide-mouthed containers that are easy to clean and disinfect. The interval between milking and pasteurization should not exceed four hours. Provisions must be made to protect the milk from sunlight and dust.

- Use tanks or containers with wide mouths, smooth surfaces, and rounded edges. Avoid porous containers (calabash, traditional gourd) and those with restricted openings (oil and water drums).
- It is essential to transport the milk quickly to the collection center or dairy (ideally within three hours of milking, to allow for one hour of milk processing if not refrigerated).
- Clean, disinfect, and dry the transport containers.
- Disinfect the containers at the dairy whenever possible.
- It is essential to clearly determine the origin of the milk collected by each collector. To avoid combining milk from different villages and rejecting large quantities of milk, the "solidarity groups" of farmers will be relatively limited. Indeed, if the quality of milk from one of the producers in the group is poor, it will contaminate the entire batch, which will be rejected after inspection at the dairy.
- It will therefore be up to farmers in the same group to take responsibility to avoid such situations (self-checks).
- Train collectors in personal hygiene and clothing standards.

Furthermore, the use of lactoperoxidase (an inhibitory agent for *Lactobacillus* sp and *Sreptococcus* sp, and a bactericidal agent for *Pseudomonas* sp and *E. coli*) could be an effective measure to minimize the quantity of bacteria during transport. This compound ensures satisfactory bacteriological quality of the milk all the way to the dairies, despite the rise in temperature during transport (figure 31).

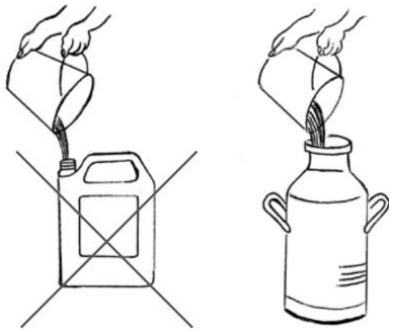


Figure 31: Milk transport: favor wide-mouth containers

IV.8.4. Checking milk quality upon receipt

Dairy processing units can use raw cow's milk or powdered milk as raw materials.

IV.8.4.1. Users of raw cow's milk

The major risk when receiving milk is the combination of contaminated milk with clean milk. Indeed, farmers supply milk in small quantities, ranging from a few liters, which is then mixed and pasteurized in pans containing several dozen liters. Thus, a container of contaminated milk contaminates an entire pasteurization batch.

Returning uncleaned cans from the dairy to farmers encourages the proliferation of microorganisms. It is therefore essential to establish simple and economical methods to identify undesirable microorganisms present in raw milk and to remove impurities. It is advisable that these checks be carried out in the presence of the farmer or collector who brings the milk. Tests must be conducted on each collector's milk before mixing. If the result is positive, the processor may ask the collector to separate the milk from each farmer the next day to identify the source of the problem. In all situations, if a milk is deemed non-compliant following these analyses, it must be rejected. In addition, the density of the milk must be checked in the presence of the supplier. Any wet milk (that has been diluted with water or

partially skimmed) must be rejected upon receipt.

IV.8.4.2. Milk powder users

Milk powder is often assumed to be of good sanitary quality because it is imported, but this is not always the case. Potential sources of contamination are mainly associated with the cleanliness of the containers and tools (spoons, spatulas) used during sampling.

If these containers are not properly cleaned, they can harbor pathogenic microbes that will be found in the milk powder during collection. Furthermore, if the handler is infected, they can transmit the contamination by accidentally putting their hand in the bag.

IV.8.4.2.1. Controls

Practices prior to processing have an impact on the hygienic and sanitary quality of milk. It is therefore essential to establish simple and cost-effective methods to identify undesirable microorganisms present in raw milk and to remove impurities. It is recommended that these checks be carried out in the presence of the farmer or collector supplying the milk (figure 32). Any milk identified as non-compliant must be rejected.

- Impurities are removed by filtering the milk upon receipt. This is done using disposable filters or equipment (including fabrics) that are cleaned and disinfected after each production run. Milk filtration removes any impurities and various residues (hair, fur, straw) that may harbor microorganisms.
- It is recommended to clean and disinfect the carboys used to transport the milk after they leave the dairy, following receipt of the milk.
- The use of basic tests helps identify milk that is unfit for human consumption.

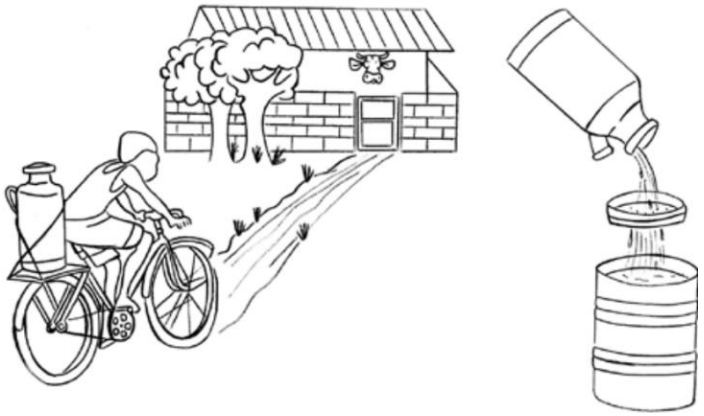


Figure 32: Milk filtration upon receipt

IV.8.4.2.2. Some simple tests to detect milk unfit for consumption

- The boiling test provides information on the organoleptic (acidification) and microbiological (possible proliferation of harmful germs in the milk) quality of the milk. Indeed, if the milk is exposed to ambient conditions after milking (during transport, for example), the germs present multiply and cause the milk to acidify. The boiling test therefore allows us to anticipate the milk's behavior during pasteurization.

- Acidity is the expression of the acidic or basic character of milk. Milk is said to be acidic when the acidity increases to a certain threshold and the milk curdles and precipitates during a heating test. It is the bacteria present in the milk that break down the lactose to produce lactic acid. Acidity is therefore an indicator of milk quality and can also be detected by the boiling test. Upon leaving the udder, healthy cow's milk has a natural acidity between 15 and 21°D.

- The California Mastitis Test (CMT) is a test that indirectly measures the leukocyte count in milk. This leukocyte count reflects the level of udder infection and is manifested by the formation of a gel when the mastitis milk is exposed to the CMT reagent; the gel is the result of the clumping of milk cells by the CMT reagent; the more cells there are, the thicker the gel will be.

- There are also other simple tests for monitoring the overall bacteriological quality of milk (mastitis test, acidity, lacto-fermentation, etc.).

IV.8.5. Controlling the quality of raw materials

Water can be a potential channel for microbial contamination due to its intensive use upstream and downstream of the milk processing process. The water source used by dairy

processing units is primarily the national water distribution network (ONEA). Before being distributed to homes, this water undergoes purification processes at treatment plants, the objective of which is to make it potable.

Generally, tap water is free of pathogenic germs and can be drunk without significant health risks. However, several factors can compromise the quality of this water during distribution. Soil microorganisms contained in groundwater can find their way into the water through breaks caused by the deterioration of obsolete pipe walls.

Processing units without running water use containers (tar-coated drums, barrels, cooking utensils, etc.) for transport and storage. Most of these are washed without specific disinfection. Consequently, their internal surfaces can serve as harborages for a large number of pathogenic germs that can pollute the water.

Water and dairy products can also be contaminated by those who handle them: an individual leaving the restroom and returning to their activity without washing or disinfecting their hands, for example. Fecal coliforms or *Enterococcus* sp, often identified as responsible for foodborne illness, are generally the pathogens involved. Other ingredients such as ferments (from previous production, store-bought yogurts or poorly stored freeze-dried ferments), sugar, flavorings and fruits can be vectors of contamination, especially if their storage (at the supplier and then at the processor) is not ensured under optimal conditions.

IV.8.5.1. Controls

IV.8.5.1.1. Water

The water used for cleaning and processing equipment and facilities must be potable. For processors using borehole water, a borehole water analysis certificate guarantees its quality.

However, transporting water in barrels does not guarantee product quality. Processors will have direct access to municipal water or a well to process dairy products.

It is recommended to have barrels equipped with opening mechanisms for cleaning and disinfection. Processors that do not yet have direct access to municipal water should use this type of barrel for their supplies. An analysis of the water used in the installation can also be carried out: verification of the presence of thermo-tolerant coliforms and faecal streptococci, but also an examination of the total flora at 22°C and 37°C as well as spores of sulfite-

reducing anaerobes.

IV.8.5.1.2. Cultures

Controlling the fermentation process plays a key role in producing a safe final product. In this context, processors should favor the use of freeze-dried cultures, which are safer and free from contamination, whenever possible. These cultures contain specific strains that promote optimal milk fermentation.

If the use of yogurt as a culture is unavoidable, it is preferable to use yogurts of recognized "quality." Cultures must be stored under appropriate conditions, i.e., at 6-8°C, and the number of subcultures must be limited to four before changing cultures.

IV.8.5.1.3. Other raw materials: powdered milk, sugar, flavorings, etc.

Processors must also ensure the quality of powdered milk, sugar, flavorings, and fruit. They must, as far as possible, check the information on the label and/or import certificates, as well as the optimal shelf life. Storage conditions must be adapted both at the distributor and at the processor (separate space or closed cabinet) (figure 33).

Figure 33: Storage of raw materials in a closed area.

IV.8.6. Personnel

All individuals working in dairy plants or occasional visitors constitute a significant source of microbial contamination. The sources and vectors are mainly derived from:

- The physical condition of staff or visitors. Some may carry microorganisms, such as

Salmonella sp (if they have had salmonellosis or typhoid fever in the past), *Staphylococcus* sp (if they have suffered respiratory infections or injuries), and coliforms (in the case of intestinal infections). Even in the absence of apparent clinical symptoms, staff can carry germs (such as those of typhoid fever or tuberculosis) and contaminate milk during processing, including after pasteurization;

- Microorganisms naturally found on hair, hands, clothing, or even shoes. Indeed, if the products are handled with inappropriate clothing, potentially present germs can contaminate the milk. Staff in contact with the product are not always aware of basic hygiene rules: wash hands with soap after each visit to the toilet, wear clean clothes. Furthermore, the required hygiene devices are not systematically present within the unit.

IV.8.6.1. Controls

Staff are crucial to ensuring food quality. Proper hygiene training is a key factor in ensuring quality. Conversely, if staff are not properly trained or do not commit themselves, they can become a major source of contamination due to their sanitary conditions, clothing, or work methods (figure 34).

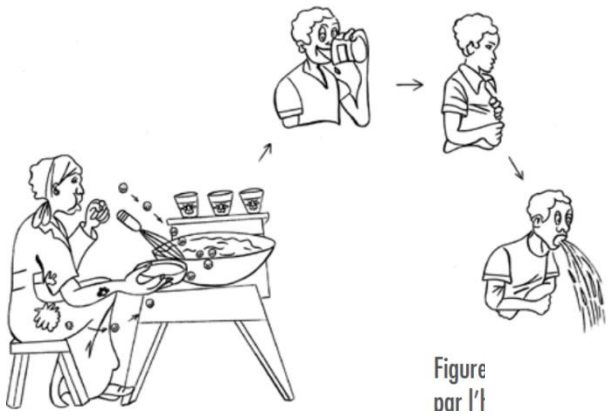


Figure 34: Product contamination hazards due to operator hygiene.

V.6.1.1. Training

It should primarily focus on good manufacturing and risk management practices. It will be the responsibility of the company manager and/or production manager to raise awareness among the rest of the staff using the methods they deem appropriate.

V.6.1.2. Medical examination

Milk quality is closely linked to the health of personnel working in dairy production units, particularly those who come into direct contact with raw materials. Indeed, nasal and pharyngeal mucous membranes, purulent lesions, and the skin can be home to various pathogens. When coughing, sneezing, or contact with contaminated skin, microbes released by the body can be transmitted to the milk.

Anyone who comes into contact with milk must undergo regular medical examinations to detect and treat any potential illnesses. These examinations should primarily focus on diagnosing tuberculosis and typhoid fever. It is imperative to conduct a systematic medical examination, even in the absence of obvious clinical symptoms in the person concerned (figure 35). In addition to diagnosing tuberculosis and typhoid fever, other secondary tests may be performed, such as the detection of KOP (cysts, eggs, parasites in the stool), as well as the assessment of albumin and glucose in the urine. If a suspicious cough or any other symptom of illness is observed, medical consultation is necessary, and admission to the unit should be prohibited until recovery (and the patient is safe).

IV.8.6.1.2. Operator hygiene

Nails must be clipped. It is imperative to wash and disinfect your hands before handling the product and after each use of the toilet. After washing, dry your hands with a clean cloth or disposable paper towels (figures 36, 37, 38).

Figure 35: Visit to the doctor

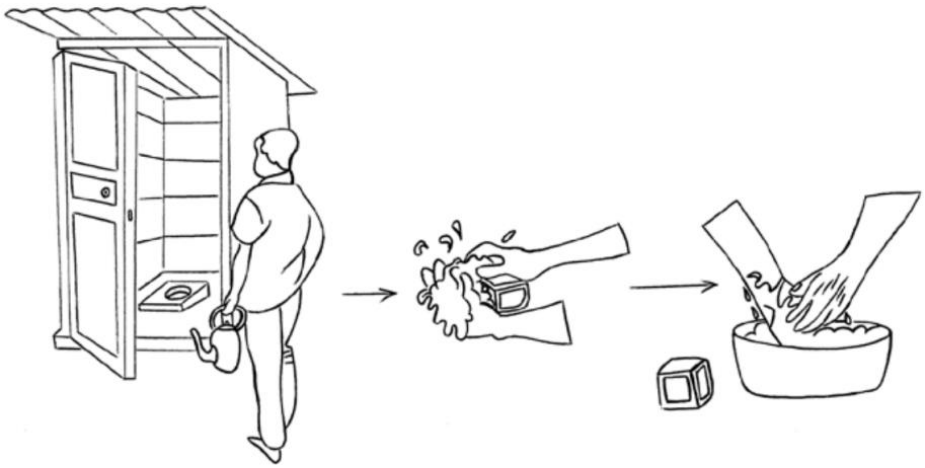


Figure 36: Washing hands after using the toilet.

Figure 37: Handwashing method

Figure 38: Wear specific clothing and provide a storage closet

Individuals with long hair must tie it back. Any jewelry must be removed. It is imperative to wear a headdress and appropriate clothing (clean and intended solely for processing), and to keep outside clothing away from the processing room or store it in a closed closet.

Before handling the product, wounds and cuts must be disinfected and protected.

Individuals identified or suspected of being ill or carrying a disease transmissible through milk and dairy products should not be allowed access to areas where milk and raw materials are handled if their presence could result in contamination of these products. Individuals in contact with milk, ingredients, and dairy products should refrain from any actions that could contaminate the products, such as smoking, spitting, chewing or consuming food, touching it with their fingers, applying nail polish or perfume to their hands, sneezing, or coughing near unprotected food (figure 39).

Figure 39: Disinfection and protection of wounds

IV.9. Process: Manufacturing steps to monitor and control

IV.9.1. Cooling or cold storage

Under ambient conditions, fresh milk can be kept for an average of 4 to 5 hours without any prior preparation. To keep milk fresh for three to four days, it must be stored in a clean, airtight container at a temperature of approximately 4°C.

If milk is to be transported prior to processing, it is essential to ensure that it is cooled within two hours of milking. Milk must also be kept away from light, as it is very sensitive to it.

IV.9.2. Systematic pasteurization of milk

Pasteurization is one of the most crucial phases in the dairy processing process. Many bacteria can contaminate milk, including those responsible for tuberculosis and brucellosis. The destruction of microorganisms cannot be carried out if pasteurization is poorly executed (insufficient time-temperature combination) or if the initial bacterial load is considerable.

Pasteurization consumes a lot of energy, but stopping heating before reaching the pasteurization temperature poses a risk since not all germs will be eliminated. A major flaw to avoid in a natural milk processing facility is poor pasteurization management. Furthermore, not all processing units are equipped with a thermometer, which can be dangerous since the milk temperature is not monitored. When milk is reconstituted from powder, the pasteurization step is not systematically performed by processors.

IV.9.2.1. Controls

IV.9.2.1.1. Pasteurization of raw milk

Milk must be clean from the moment of milking. Milk taken from a healthy animal usually contains a low number of microorganisms. These microorganisms are generally saprophytes present in the udder and milk ducts, such as lactic *Streptococcus* sp, *Micrococcus* sp, and *Lactobacillus* sp. Lactenin, an enzyme naturally present in raw milk, inhibits the multiplication of microorganisms for approximately 4 hours. This phenomenon is called the raw milk "bactericidal" or "adaptation" phase. These enzymes facilitate the transport of milk without the need for cooling, provided that the unrefrigerated storage time (until processing) does not exceed the duration of lactenin activity.

In addition to the initial flora, other bacteria from various sources (milking equipment, milker's hands, air, buckets, water, etc.) can contribute to intensifying the microbial load. This load increases significantly if the milk is stored for long periods at ambient conditions (20 to 40°C) during its transport to the facility. Therefore, even if milking is carried out under appropriate hygienic conditions, subsequent contamination can occur. It is therefore essential to pasteurize the milk upon arrival, before any processing.

Pasteurization, in essence, is a thermal procedure that involves raising the temperature of the milk to a certain level and maintaining it for a specific period. The majority of non-spore-

forming bacteria present in the milk are eliminated by the pasteurization process. However, a certain number of them, called heat-resistant bacteria, survive and can reproduce when conditions return to favorable conditions. This is why *Streptococcus* sp and *Lactobacillus* sp can persist in insufficiently pasteurized milk, leading to its acidification (the start of the fermentation process) and the coagulation of casein.

If the quality of the raw milk is guaranteed by the processing unit, pasteurization can be performed using three temperature and heating time parameters:

- at 95°C for 1 second for instant pasteurization;

- at 75°C for 15 seconds for high-temperature pasteurization;

- at 63°C for 30 minutes for low-temperature pasteurization.

The efficiency of pasteurization depends heavily on initial microbial contamination and strict adherence to the selected temperature-time combination. Therefore, it is essential to use a thermometer and a watch. For small-scale units, it is recommended to follow the "at least 90°C for 10 minutes" or "85°C for 20 minutes" protocol, as this ensures consumer protection. This is verified using a thermometer. If operators do not have thermometers available, they can boil the milk in a bain-marie for a short time and then quickly cool the product.

- Respect the time-temperature ratio. The best practice guide recommends "90°C for 10 minutes."

- Use appropriate methods: the best method is water bath pasteurization.

- If the pasteurized milk is not processed, cool it within one hour of pasteurization and store it at a temperature of 6-8°C to limit the growth of potential microorganisms.

- Always filter the milk before pouring it into the pasteurizer.

To ensure effective monitoring and management of pasteurization, it is advisable to record the actions performed for each production run. It is recommended to keep the records in a dedicated binder to provide the dairy with a production history (figure 39).

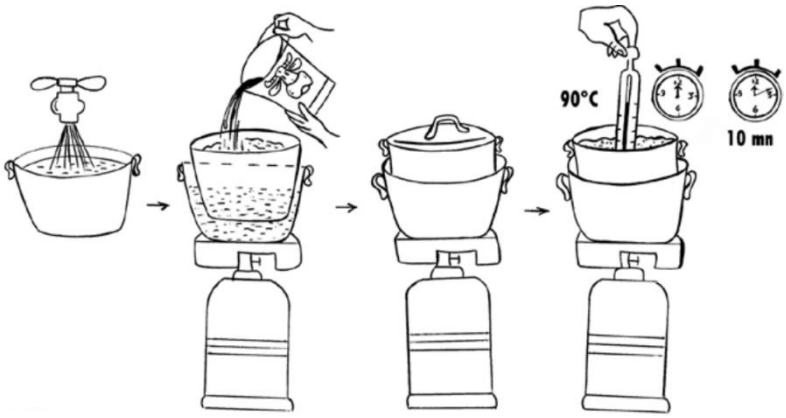


Figure 39: Pasteurization of milk at least 90°C for at least 10 minutes

Using a higher temperature, and/or for a longer period of time, also eliminates microorganisms. However, a lower temperature and/or a shorter time does not guarantee consumer safety. The company manager will emphasize the importance of respecting the time-temperature ratio, always favoring an additional margin (either more time or higher temperature) when in doubt.

In terms of health, pasteurization eliminates the microbes responsible for tuberculosis and brucellosis. However, pasteurization does not eliminate all risks or all varieties of bacteria. It does not eliminate spores, which pose a potential risk of foodborne illness. This is why it is necessary to keep pasteurized milk at a temperature of 4°C to limit the proliferation of potential microorganisms.

IV.9.2.1.2. Pasteurization of reconstituted milk

Although milk powder has a water activity that prevents the proliferation of microorganisms, and processes such as spray drying or instantization have reliable bactericidal action, there is a risk of recontamination (by *Salmonella* sp, *Staphylococcus aureus*, *Escherichia coli*, yeasts, molds, etc.) that can occur subsequently, particularly during the humidification process during storage at the point of sale.

Furthermore, the water widely used for reconstituting milk can be a potential vector for microbial contamination. Generally, water from ONEA distribution networks meets the potability standards required for consumption at the station outlet. However, its quality can deteriorate during its transport through the pipes (due to defective pipes and leaks) to the

various distribution points. Water can also be contaminated by poorly maintained or unsanitized containers (barrels, buckets, etc.), which often harbor a large number of pathogens.

It is therefore essential to pasteurize reconstituted milk before processing it. This heating process eliminates or reduces harmful germs and (vegetative) changes present in milk and water.

IV.9.3. Cooling milk after pasteurization

As previously mentioned, pasteurization does not completely eliminate microorganisms, which remain in the form of spores. The higher the temperature, the greater the risk of microbial proliferation. Furthermore, an inoculation temperature that is too high can inactivate or weaken the starter culture, or fail to stimulate the desired bacteria.

When cooling is carried out gradually, spores (which prefer a temperature close to room temperature for growth) can germinate and multiply in the milk. As they grow, these germs will outcompete the activity of lactic acid bacteria, thus hindering optimal milk fermentation.

Beyond the deleterious effect of germinated bacteria, it is important to highlight the significant contribution of other bacteria from the surrounding environment and contaminated surfaces (accumulation of dust).

IV.9.3.1. Controls

Cooling must be rapid and immediately followed by the addition of the appropriate ferment at the optimal temperature:

- 40-45°C for fast-fermenting yogurt;
- 37°C for slow-fermenting yogurt;
- 31-37°C for curdled milk;
- 4°C for pasteurized milk.

The milk must be cooled in closed basins in a water bath of fresh water.

IV.9.4. Fermentation

Analysis of this phase highlights two main hazards.

IV.9.4.1. Using poor-quality starter cultures

Using a yogurt from a previous production to inoculate the next batch does not ensure product quality. If the starter culture is infected with pathogenic microorganisms, it risks contaminating the next batch of yogurt. Furthermore, with each successive subculture, the effectiveness of the starter culture tends to decrease, slowing the product's acidification and allowing more time for pathogenic microorganisms present in the milk to multiply.

Using store-bought yogurt can pose the same risk if the starter culture composition is not balanced. Improper use or storage (do not use starter cultures that have passed their best-before date) of freeze-dried starter cultures can lead to product contamination.

IV.9.4.2. Poor control of fermentation technology

The ferments used, the level of inoculation, as well as the fermentation duration and temperature influence not only the organoleptic quality of yogurts (irregular fermentation with an alcoholic taste, excessive production of yogurts on the market, marked acidity), but also their sanitary quality (presence of undesirable and pathogenic microbes), and finally the profitability of the business (defective fermentations that prevent the product from being sold, presence of bacteriophages).

IV.9.4.3. Control methods

IV.9.4.3.1. By the action of lactic acid flora (fermentation)

The transformation of lactose into lactic acid by lactic acid bacteria is the cause of milk fermentation. The generation of this acid causes a decrease in the pH of the environment, which leads to protein coagulation. When the fermentation process takes place slowly in the open air, the spores (which prefer a temperature close to room temperature for their growth) have the opportunity to germinate and multiply in the milk. As they grow, these microorganisms will outcompete the activity of the lactic acid bacteria, thus compromising effective acidification. The latter is a considerable advantage in terms of hygiene and health, as it prevents the proliferation of the majority of unwanted germs.

To optimize fermentation, it is essential to respect the inoculation and incubation

temperatures to ensure the hygienic and technological quality of the final product. This temperature should be close to the ideal temperature for germ proliferation or the one that activates the enzyme.

- **For curdled milk** (fermentation culture composed of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*): For the fermentation culture containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, a temperature close to the ideal temperature for the development of mesophilic streptococci, i.e., 31°C, is chosen. It should be noted that the ideal temperature for the growth of *Lactobacillus bulgaricus* is between 47 and 50°C; however, it is recommended that the *Streptococcus thermophilus* strain initiate the fermentation process. The goal is to favor these individuals, which are responsible for flavor production. *Lactobacillus bulgaricus* are indeed powerful acidifiers capable of generating significant amounts of lactic acid at a temperature of 47°C. At a temperature of 31°C, their acidifying capacity decreases sharply, which favors the formation of a fragrant curd with an acidity of approximately 80°D after 18 hours.

- **For yogurt:** it is best to prepare it from two bacterial strains: L*actobacillus bulgaricus* and *Streptococcus thermophilus*. They will be inoculated at the same time and will remain alive until the product is consumed. It is crucial to inoculate at a temperature as close as possible to 45°C to ensure that fermentation starts as quickly as possible. Whenever possible, it is recommended to use an oven or insulated cabinet.

- **For cheese** (rennet curdling): Process management depends on the type of enzyme used, such as rennet curdling. The plant extract of *Calotropis procera* contains an enzyme that activates at high temperatures (from 65°C). The enzyme from calf abomasum works effectively at a low temperature of around 33°C, with an acidity level varying between 19 and 25°D.

The curd obtained through the action of rennet has a less marked acidity than that produced by lactic acid bacteria. This is why "rennet" curd is a product more prone to the proliferation of microorganisms than yogurt. Its production requires strict hygiene standards and, more particularly, impeccable observance of the cold chain.

IV.9.5. Packaging and labeling

Packaging is the phase where the product is packaged in a sachet or tub. It is therefore no longer subject to any additional handling. After this stage, it is impossible to eliminate microorganisms that may be present in the product and that would develop if the conditions are right (particularly temperature and acidity).

Yogurts with lower acidity, particularly those where the starter culture is less than ideal, are most likely to develop bacteria. At this stage, three main sources of contamination can be considered:

- Packaging: although the milk or yogurt is free of any contamination, packaging that is stored in poor conditions or is poorly cleaned and disinfected can contaminate the product sold;
- Certain inappropriate methods used by operators during packaging: blowing into the sachet to open it, packaging the product under a poorly cleaned fan (increased risk of contamination by bacteria present in the surrounding air);
- The work environment and personnel (clothing, jewelry, etc.), potential sources of product decontamination.

IV.9.5.1. Control methods

- It is recommended to disinfect the jars before use. Packaging machines will also be washed and disinfected after each production run (figure 40).
- Appropriate packaging methods are applied: avoid blowing open the bags (figure 41).

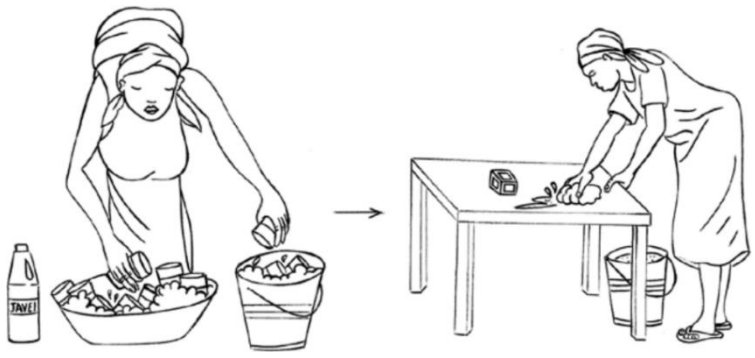


Figure 40: Washing and disinfection of packaging and the packaging table.

a b

Figure 41: a: Danger of contamination due to poor packaging practices; b: Good packaging practices.

- Labeling must be done post-packaging to prevent any possible contamination of the jars by labels. Product labeling must include the unit name and address, the expiration date, the production batch number, and the storage conditions. Indicating the manufacturing date and the best-before date is an essential tool for ensuring product traceability and can replace the batch number for small businesses.

IV.9.6. Cooling the finished product

After packaging, the products are chilled in a refrigerator. While packaging time is crucial, it is essential to refrigerate packaged products gradually rather than waiting until the end of the process.

IV.9.7. Compliance with the cold chain at delivery and at the distributor level

It is not always guaranteed that products are stored in appropriate conditions at the processor. Some refrigerators may not function properly or lack the capacity required for rapid cooling of products, especially during the summer. Not all processors are equipped with a thermometer to monitor refrigerator temperatures, which means that the temperature does not always reflect the conditions required for product preservation.

Furthermore, if refrigerators are not regularly cleaned and products are not properly organized (avoiding mixing them with other products such as juices, meat, etc.), the risk of contamination increases. Some processors provide "hot delivery." The yogurt is shipped directly after packaging.

Although this is not beneficial to product quality, this approach is appreciated by the

processors involved and the distributors who work with them. The latter benefit from significant savings in terms of energy and time, since they do not need to refrigerate the product. The latter can be sure of receiving the daily production, which guarantees freshness and therefore quality.

Transportation and storage at the supplier's premises pose risks of contamination or interruption of the cold chain. Frequent power outages or the practice of temporarily disconnecting refrigerators to save energy cause food temperatures to rise, which can promote bacterial growth. Furthermore, the risks of contamination are identical in the distributor's refrigerator and the processor's refrigerator. It is unacceptable to allow customers to open yogurt containers at the distributor's premises, as this poses a significant risk of contamination.

IV.9.7.1. Controls

It is the manufacturer's responsibility to ensure that, if stored properly, their products remain perfectly edible until the specified date (use by date, indicated as "Use by DD/MM/YY"). Studies conducted by the FAO show that, when produced using strict processes and in a hygienic environment, pasteurized milk can stay fresh for up to eight days at a temperature of 4 to 6°C. Yogurts and curdled milk can be stored for approximately three weeks, provided they are kept refrigerated.

When sold, the temperature must be maintained at 8°C or lower for fermented milk products and between 4 and 6°C for pasteurized milk.

In cases where cold chain control is not ensured from the manufacturer to the consumer, distribution and consumption times must be significantly reduced.

It is necessary to keep products cool (in a refrigerator) before distributing them to the various sales locations. It is essential that refrigerators are well maintained (control the temperature), hygienic and tidy (avoid stacking different foods on the same shelf). If your refrigerator contains various products, it is advisable to place dairy products on the upper shelves (figure 42).

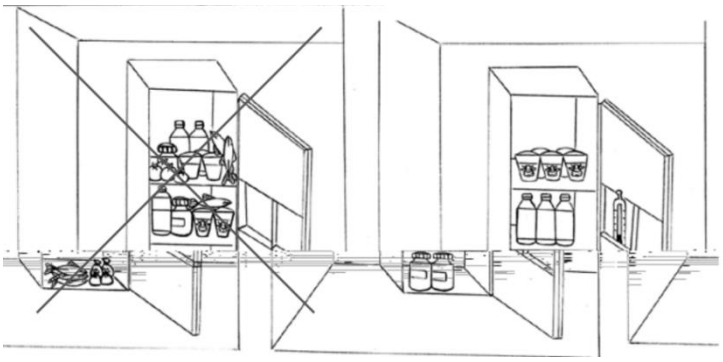


Figure 42: Product storage in the refrigerator.

Regarding organoleptic properties, the objective of a low temperature is to slow the proliferation of lactic acid bacteria and prevent significant acidification of the milk. From a hygienic perspective, maintaining the finished product at a cool temperature prevents the possibility of further proliferation of pathogenic germs. Processors must prevent any interruption in the cold chain that would encourage the proliferation of previously controlled microorganisms. Delivery equipment must be capable of maintaining a cold temperature for yogurts without interrupting the cold chain (insulated equipment).

IV.10. Clean equipment and efficient storage

Being in constant contact with the raw material, equipment is a significant source of contamination. Items such as sieves, wooden spatulas, and poorly or insufficiently cleaned cloths (or fabrics) can adversely affect product quality. Insufficient cleaning (and disinfection) generally leaves organic residues where microorganisms can multiply and contaminate the milk upon first contact.

Wooden sieves and spatulas can be used in various ways during processing, which can lead to cross-contamination. Furthermore, these wooden elements can harbor microorganisms (such as molds, saprophytes, and pathogens) in their micropores, which can then contaminate the milk.

Regarding fabrics and cloths used for filtration, they can become sources of contamination if reused without prior cleaning and disinfection (essential to remove residues, which provide an ideal environment for the development of unwanted germs).

IV.10.1. Controls

The equipment used during various operations or during storage poses a risk of contamination (before pasteurization) and recontamination (after pasteurization). This risk increases when this equipment is inappropriate (made of wood, iron, or small) or poorly disinfected (presence of organic matter, biofilm).

Thus, processing equipment must be cleaned, sterilized, dried, and organized before and after each production run. Materials such as aluminum or plastic should be preferred to ensure effective disinfection. These must be strictly dedicated to milk processing (figure 43).

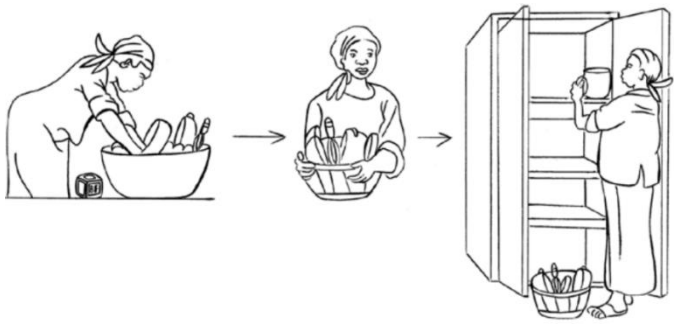


Figure 43: Equipment washing and storage

IV.11. Well-Designed premises, maintained cleanliness in a clean environment

Processing areas and spaces could be potential sources of product contamination. One of the main reasons is the lack of hygiene on floors, walls, ceilings, and other contact surfaces. Airborne particles and pathogenic strains can be found in organic debris on the floor and cobwebs on the ceiling, and the latter can contaminate the milk during various handling operations.

The entry and exit of visitors and the presence of animals are also potential sources of contamination, as is the contact between "dirty" and "clean" products, which poses a risk of cross-contamination. For example, if the delivery point where the milk arrives in unwashed containers is located near the yogurt packaging site, there is a risk that microorganisms present on the container surfaces could contaminate the containers.

IV.11.1. Controls

Improper design and installation of spaces, contact surfaces, and ambient air pose risks of

microbial contamination of milk.

IV.11.1.1. Appropriate design of premises

It is recommended that processing be carried out in an enclosed space, protected from dust and pests (flies, rats, mice, cockroaches, etc.). Food processing facilities must adhere to the "forward flow" principle. Generally, the product is quite contaminated upon receipt of raw materials, and it is imperative that it be pure at the end of the production process. The "forward flow" concept stipulates that "clean" and "dirty" product flows must remain separate.
- Spatial progression applies to units that have adequate space and perform a single processing activity. The objective is to divide each operation into separate sectors to prevent contamination between "raw" raw materials (such as milk cans upon arrival at the receiving point) and semi-finished or finished products (such as packaged or unpackaged yogurt).
- Temporal progression applies to smaller processing units. It is impossible for most small-scale businesses to constantly dedicate several rooms to processing activities. They can therefore implement this concept: the various tasks are spaced out over time, and the spaces are sanitized and disinfected between tasks. Therefore, processing can be carried out in a room generally intended for other purposes, provided that the premises are properly prepared before the production process and that the equipment is also cleaned and disinfected.

At a minimum, you should plan for:
- A separate room for receiving milk, storing raw materials, cleaning products, and clothing in three closed cupboards;
- A room designed for processing with closed cupboards (for equipment).

This principle can be applied, in particular, to units using the time progression approach. However, if the company has greater resources, it would be advisable to consider at least four rooms:
- A space for receiving milk and storing clothing in a closed cupboard;
- A space for storing raw materials;
- A pasteurization/fermentation room;
- A packaging room with space for storing, packaging, and finished products, and for selling

or releasing finished products (which, if possible, should be separated from the packaging).

Improvements could be made by separating the changing rooms from the milk receiving area, as both areas present a potential risk of contamination. To effectively implement this "forward march," staff must follow a program for cleaning, disinfecting, and storing equipment and utensils, as well as cleaning/disinfecting products. Wherever possible, the premises should be easy to clean, as should the equipment and table surfaces used for the processing process.

IV.11.1.2. A healthy environment

The processing facility will be set up in a clean environment, i.e., away from sources of microbial contamination (waste, etc.). Appropriate measures will be taken to keep insects and rodents at bay or eliminate them.

A wastewater drainage system must be provided. It is desirable for the floor to have a slight slope to facilitate the flow of cleaning water to a specially designed outlet.

IV.11.1.3. Efficient storage

Processing equipment will be carefully stored in cabinets designed to protect it from dust and contamination. Products used for cleaning and disinfection will be stored separately from raw materials intended for processing.

IV.12. Cleaning and disinfection

It is imperative to strictly apply appropriate cleaning and disinfection procedures, before, after, and regularly.

Each unit must establish and regularly implement a cleaning schedule for its premises and equipment. For smaller facilities, this schedule may include cleaning and disinfection of equipment and work surfaces after each production run (and before if there is no daily production run), as well as a complete cleaning of the facility and its surroundings (walls, floor, ceiling, and immediate area) at least once a month.

IV.12.1. Cleaning and disinfection of equipment, work surfaces, floors, and soiled

surfaces (wall splashes) after each production run (and before each run if the previous run was not the day before).

In the milk processing process, handling areas and equipment in contact with milk retain milk residue where microorganisms can proliferate. It is essential to clean and disinfect after each production run (figure 44).

Following this procedure, the equipment is dried and stored away from contamination. It is prohibited to dry cloths, staff uniforms, and equipment outside the dairy due to the risk of contamination by flies and dust. It is recommended to dry them in a closed room, then iron the clothes and cloths.

Figure 44: Cleaning and disinfection of the processing room

IV.12.2. Periodic cleaning of the unit

The unit is completely cleaned and disinfected as needed, at least once a month: walls, ceilings, windows, surrounding areas, etc. Any damage to paint or coatings will be repaired. The fan blades will be dusted at least once a week (figure 45).

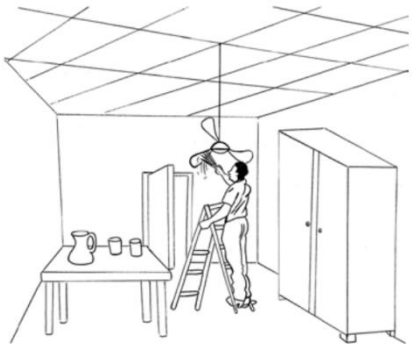


Figure 45: Cleaning fan blades

IV.12.3. Use of suitable disinfectants and cleaning products

Soap, such as dishwashing liquid, is an excellent degreaser. If its quality is adequate, bleach is an effective disinfectant. It is recommended to avoid using sponges (which retain microorganisms), and instead use cloths or a nylon brush, which are easier to clean.

It is not recommended to use abrasive powders and liquids, or scouring sponges, as they can cause scratches that can serve as harborages for microorganisms. It is becoming increasingly difficult to thoroughly clean surfaces, particularly those of airtight containers, buckets, and plastic utensils.

Cleaning and disinfection of dairy processing equipment may therefore include both a degreasing and a disinfecting agent.

There are also other disinfection products. It is recommended to choose approved products with a broad range of effects on microbial flora. To ensure their effectiveness, it is crucial to pay particular attention to the quality of the detergent (active ingredient) and to use it in accordance with the manufacturer's recommended concentration and contact time.

For health reasons and because milk has the ability to absorb odors, it is imperative to store cleaning products in well-sealed storage areas, away from raw food materials.

Two disinfection methods could be recommended for small-scale dairy processing facilities:

- **Chemical disinfection:** The most commonly used disinfectant is bleach, whose active ingredient is chlorine. It is important to follow the recommended dosages for its use. It is generally recommended that the concentration of the disinfectant solution (bleach) be 200 mg per liter of active chlorine. The effectiveness of bleach depends not only on its concentration but also on the time it spends in contact with the surface to be disinfected.

It is recommended to leave it on for 15 minutes to eliminate bacteria and more than 30 minutes to eradicate viruses.

It is also necessary to rinse the treated surfaces with hot water to remove the disinfectant. After this washing, the instruments are wiped dry and stored in a clean area until their next use. Processors must monitor the quality of the bleach used (including checking its expiration date).

- **Heat disinfection**, which involves immersing the utensils in boiling water for 5 minutes.

This approach is more rigorous than the previous one, however, the sometimes poor quality of bleach available on the market may encourage some processing plants to opt for it.

Bibliographic references

AFSCA. 2012. Guide d'autocontrôle pour la production et la vente de produits laitiers à la ferme. Agence fédérale pour la sécurité de la chaîne alimentaire. G-034 version 1 du 23-07-2012. 199 pages.

Ait Ouahioune M., Belaid D. 2020. Impact de la démarche qualité/environnement selon le référentiel ISO sur la performance de l'entreprise dans le cadre de la problématique du développement durable cas: ENIEM. Doctoral dissertation, Université Mouloud Mammeri.

Amari K., Chender O. 2021. La médecine du travail: Prise en charge des accidents de travail et maladies professionnelles. Doctoral dissertation, Université Mouloud Mammeri.

Amiard Jean-Claude. 2011. Les risques chimiques environnementaux. Méthodes d'évaluation et impacts sur les organismes. Lavoisier.

Akhmetsadykova S. 2012. Impact de la pollution sur la qualité du lait de chamelle au Kazakhstan. Thèse de doctorat Biotechnologie, Microbiologie. Centre international d'études supérieures en sciences agronomiques, Université Nationale Kazakh al-Farabi. 172 pages.

Anglade P. Centre fromager de Carmejane. La fromagerie à la ferme : concevoir, réaliser, équiper son atelier de transformation du lait à la ferme. Centre fromager de Carmejane; Méthodes et Communication. 1998. 207 pages.

ATLA/Actilait. 2012. Guide de bonnes pratiques d'hygiène et d'application des principes HACCP pour la collecte du lait cru et les fabrications de produits laitiers. Collecte de lait cru et fabrication de produits laitiers. Législation et réglementation, guides de bonnes pratiques d'hygiène. Les éditions des Journaux officiels. 345 pages.

Aubertin M., Bussière B., Bernier L., Chapuis R., Julien M., Belem T., Li L. 2002. La gestion des rejets miniers dans un contexte de développement durable et de protection de l'environnement. Congrès annuel de la Société canadienne de génie civil, 5-8.

Azni M., Akziz F. 2022. La gestion des risques professionnels dans l'entreprise publique, cas électro-industries «ELECTRO-INDUSTRIES» *AZAZGA.* Doctoral dissertation, Université Mouloud Mammeri.

Bardou J.P. 2020. Santé et sécurité au travail: de la complexité à l'effectivité. Proposition d'un guide de bonnes pratiques de prévention des risques professionnels. Doctoral dissertation, Université de Bretagne Sud.

Baril-Gingras G., Fournier P.S., Montreuil S. 2014. L'intervention en santé et en sécurité du travail: pour agir en prévention dans les milieux de travail. Presses de l'Université Laval.

Berche P., Louis J., Simonet M. 1991. Bactériologie : les bactéries des infections humaines. Médecine-Sciences Flammarion. Paris, 1991.

Bernillon A., Cerutti O. 1995. Les outils du management de la qualité, le guide du gestionnaire.

Beuchat Larry R. Pathogenic microorganisms associated with fresh produce. Journal of food protection 59.2. 1996: 204-216.

Bignon E. 2010. Amélioration de la qualité des laits biologiques : caractérisation des micropolluants. Institut technique de l'agriculture biologique (ITAB). 110 pages.

Bley D., Pecaud D., Raude J., Cardoso E., Rougeyron F., Vernazza-Licht N. 2017. Représentation des dangers et définition des risques sanitaires dus à l'installation d'Aèdes Albopictus dans les territoires métropolitains. Doctoral dissertation, MEDDE.

Bonfoh B. 2002. Lait sain pour le Sahel. Atelier de restitution des résultats «hygiène et qualité du lait et des produits laitiers au Mali» : implications en production laitière et en santé publique. CILSS-STI-ETH. 2002. 50 p.

Bonfoh B. 2003. Résumé des communications du séminaire régional «Lait sain pour le Sahel : production, approvisionnement, hygiène et qualité du lait et des produits laitiers au Sahel». Bamako, 2003. http://www.laitsain.com/files/resumes_seminaire_03_03. pdf.

Boussin H., Traoré A., Tamboura H.H., Bessin R., Boly H., Ouédraogo A. 2012. Prévalence de la tuberculose et de la brucellose dans les élevages bovins laitiers intra-urbains et périurbains de la ville de Ouagadougou au Burkina Faso. Rev. sic. tech. off. int. Epiz., 2012, 31 (3), 943-951.

Boutou O. 2014. De l'HACCP à l'ISO 22000: management de la sécurité des aliments. AFNOR éditions.

Brun P., Corréard I., Anaya P. 2011. Sécurité, hygiène et risques professionnels. Dunod.

Capo-Chichi B. 2004. Propriétés coagulantes de *Calotropis procera* et ses possibilités d'utilisation en industrie agroalimentaire. Mémoire présenté pour l'obtention du diplôme d'études approfondies en biotechnologies. Université de Ouagadougou et Université d'Abomey Calavi. 52 pages.

Chamba J.F., Delacroix-Buchet A., Berdague J.L., Clément J.F. 1994. Une approche globale de la caractérisation des fromages: l'exemple du fromage de Beaufort. Sciences des aliments, 14 (5), 581-590.

Chaslus-Dancla E. 2003. Les antibiotiques en élevage : état des lieux et problèmes posés. Résultats de recherche INRA, UR86 équipe «résistance aux antibiotiques». Responsable de publication : Vautherot J-F. 2003.

CIRDES. Rapport de l'atelier national sur la politique laitière au Burkina Faso. CIRDES. 1998. 110 p.

CIRDES. 2001. Rapport régional sur l'organisation de la collecte du lait dans les zones sans infrastructure laitière en Afrique de l'Ouest. CIRDES. 72 pages.

Codex Alimentarius. 2001. Hygiène alimentaire. Textes de base. Deuxième édition, Programme mixte FAO/OMS sur les normes alimentaires. Commission du Codex alimentarius, Rome. 2001. ftp://ftp.fao.org/codex/standard/booklets/Hygiene/fh_fr.pdf.

Codex Alimentarius. Directives pour la conservation du lait cru par le système fondé sur la lactoperoxydase (CAC/GL 131991). http://www.codexalimentarius.net/download/standards/29/CXG_013f.pdf.

De la moricière, Guy Gautret. 2008. Le risque chimique : Concepts-Méthodes-Pratiques. Dunod.

Diagne R. 2013. Sécurité alimentaire et libéralisation agricole. Doctoral dissertation, Université Nice Sophia Antipolis.

Dubé Jessica. 2018. Les pratiques préventives de santé et de sécurité au travail. Thèse de doctorat. Université de Québec à Montréal.

Dudez P. 2002. Guide pratique «Transformer les produits laitiers frais à la ferme» (France).

Dudez P., Broutin C. 2004. Les règles d'hygiène en transformation laitière - Afrique - Fiche agridoc, www.agridoc.com.

Dudez P., Broutin C. 2004. Locaux et matériels de transformations du lait : quelques conseils pour le choix des bonnes solutions - Fiche agridoc, www.agridoc.com.

Dudez P., Broutin C. 2004. Quatre méthodes simples d'utilisation pour contrôler la qualité du lait et des produits laitiers. Fiche agridoc, www.agridoc.com.

FAO/FIL. 2004. Guide de bonnes pratiques en élevage laitier. Fédération internationale de laiterie, Organisation des Nations unies pour l'alimentation et l'agriculture. 38 pages.

FAO/FIL. 2012. Guide de bonnes pratiques en production laitière. FAO Production et santé animales. Édition revue. Directives n°8. Rome. 51 pages.

Flaus J.M., Bourrières J.P. 2013. Analyse des risques des systèmes de production industriels et de services: Aspects technologiques et humains. Hermés science.

Fourar Youcef. 2021. Adhésion de l'entreprise algérienne à la stratégie participative pour l'amélioration des conditions de travail. Thèse de doctorat. Université de Batna 2.

Graine S., Mahdaoui N., Alouaoui R. 2019. Maitrise des risques industriels et la sécurité des installations.

Gramond S. 2014. La fonction sécurité, collection activité et sécurité, 3ème Edition.

Gret, Simon, Daniel, François, Martine, Dudez, Philippe. 2002. Réseau produits fermiers. Educagri éd. 237 pages.

Haddad L. née Moulahcene. Polycopié de cours: HSE: Hygiène–Sécurité–Environnement.

Hamadou S., Marichatou H., Kamuanga M. 2003. Croissance désordonnée des élevages périurbains et approvisionnement de la ville de Bobo-Dioulasso : problématique de l'hygiène du lait. Études et recherches sahéliennes. 9 pages.

Hefsi G. 2024. La gestion des risques professionnels, un facteur de motivation de la RH Cas:«ELECTRO-INDUSTRIES» AZAZGA. Doctoral dissertation, Universitité Mouloud Mammeri.

Henri Procaccia. 2009. Introduction à l'analyse probabiliste des risques industriels. Lavoisier.

Jacob E. 2016. Sécurité d'entreprise: le défi des menaces asymétriques.

Jakob E., Menendez/Gonzalez S. Guide des bonnes pratiques de la production et de la transformation du lait dans les exploitations d'estivage. Société suisse d'économie alpestre. 9 pages.

Kees M., Bio D., Guiwa C. 1994. Manuel pour la fabrication du fromage peulh. Équipe du projet « Fromage peulh ». Bénin. 20 pages.

Lambert J-C., Lhoste F. 2003. La méthode de conservation du lait cru par le système fondé sur la lactopéroxydase. L'intégration du « programme lait de brousse » au module laitier villageois. Études et recherches sahéliennes n° 8-9. 6 pages.

Laurent André. 2011. Sécurité des procédés chimiques. Connaissances et méthodes d'analyse des risques (2ème Edition). Tec et Doc/Lavoisier.

Leclercq E. 2014. Lorsque l'activité professionnelle recompose les parcours de transition: les responsables «Hygiène, qualité, sécurité, environnement». Formation emploi, 128 (4), 47-64.

Lopez S. 2024. Transformation de l'activité d'apprenants de l'enseignement professionnel en situation de presque accident: une approche énactive (Doctoral dissertation, Université de Toulouse).

Manfred Moll and Moll Nicole. Additives alimentaires et auxiliaires technologiques Dunod. 1998: 25-26.

Margossian Nichan. 2006. Risques et accidents industriels majeurs: Caractéristiques, réglementation, prévention. Dunod.

Marichatou H., Hamadou S., Kanwe A. 2003. Production laitière dans le système d'élevages périurbains en zone subhumide du Burkina Faso : situation et voies d'amélioration. Études et recherches sahéliennes. 8 pages.

Morgossian N. 2006. Risque chimique, aide mémoire, 2ème Edition.

Morre J. 1974. Les métaux, agents de pollution du lait. Leur dosage par spectrophotométrie d'absorption atomique. Mémoires originaux. Le lait 139-152.

Mourad T.I.A.R. 2024. Polycopié de cours d'hygiène, sécurité et d'environnement «HSE».

Mouton J.P. 2006. La sécurité en entreprise, 2ème Edition.

Olivier Marc. 2020. Chimie de l'environnement. Lab éditions.

Ourida A.A. 2018. Cours d'hygiène, sécurité et d'environnement.

Schneider Sebastian H. Bürgerhaushalt Oldenburg 2012/2013. Evaluations bericht. Dokumentation, Oldenburg: Zentrum für Methoden der Sozialwissenschaften (MSW) (2013).

Schriver-Mazzuoli Louise. 2009. La pollution de l'air intérieur : Sources. Effets sanitaires. Ventilation. Dunod.

Séverin M.B.O.G., Bitondo D., Innocent N.D.O.H., Patamaken S.A., Djocgoue P.F., Boyogueno E. 2020. Evaluation du niveau de prise en compte des aspects Hygiène, Sécurité et Environnement (HSE) au sein d'une industrie de savonnerie: cas du Partenaire Financier avec Christ (PAFIC). *Sciences Naturelles et Appliquées*, *39*(1), 47-58.

Sizine D., Lasmi D. 2021. Diagnostique d'état de gestion des aspects environnementaux en vue d'une mise en place d'un système de management environnemental; cas de: NAFTAL Tizi-Ouzou. Doctoral dissertation, Université Mouloud Mammeri.

Tourette I. 2002. Filières laitières en Afrique et points critiques pour la maîtrise des

dangers sanitaires des laits et produits laitiers. Synthèse bibliographique. Diplôme d'études supérieures spécialisées productions animales en région chaudes. Cirad-EMVT, Université Montpellier II. 32 pages.

Yokoigawa K., Takikama A., Okubo Y., Umesako S. 2003. Acid tolerance and gad RNAm levels of *Escherichia coli* 0157-H7 grown in foods. International Journal of Food Microbiology 82 203-211.

Yousef Ziane. 2021. Evaluation des risques majeurs par la méthode nœud papillon, et l'importance de la fiabilité humaine: cas zone de stockage des GPL au niveau de la raffinerie d'Alger. Thèse de doctorat.

Website:

https://www.sillonbelge.be /les accidents du travail.

https://www.techniques-ingenieur.fr /les catastrophes industrielles.

https://www.msdmanuals.com/fr/professional/maladies-pulmonaires/silicose.

https://scolawebtv.crdp-versailles.fr/?id=25581.