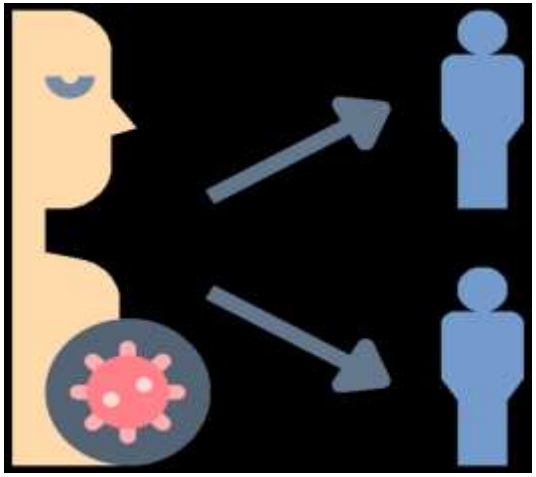
Personnel and Equipment Hygiene

- ✓ Personnel handling milk and milk products constitute one of most important sources of microbial contamination including potential pathogens in these products.
- ✓ Personnel hygiene plays significant role in influencing microbiological quality of milk and milk products which may affect health of consumers.
- ✓ Achieved by adopting food hygiene principles throughout food chain and HACCP based approach.
- ✓ Both government and industry have responsibility to provide safe and suitable milk and milk products for consumers practicing principles of food hygiene.

Food Handlers:

- ✓ Any person who directly handles packaged/unpackaged food, equipment and utensils/food contact surfaces.
- ✓ Potential sources of microorganisms that cause illness and food spoilage.
- ✓ Parts of body that contribute to contamination of food include skin, hands, hair, eyes, mouth, nose, naso-pharynx, respiratory tract and excretory organs.



Carrier is a person who harbours and discharges pathogens but does not exhibit symptoms of disease

Convalescent carriers: After recovering from an infectious disease, continue to harbour causative organism for variable length of time, usually < 10 weeks.

Chronic carriers: People continue to harbour infectious organism indefinitely, although they do not show symptoms of disease.

Contact carriers: People acquire and harbour pathogen through close contact with an infected person but do not acquire disease.

Pathogenic bacteria associated with food handlers

- Streptococci harbors in human throat and intestines and responsible for wider variety of diseases.
- Responsible for development of secondary infections.
- Staphylococci single reservoir is nasal cavity. People who possess pathogenic varieties of organism as part of their natural skin flora are a constant threat to consumer safety.
- Intestinal microorganisms such as *Salmonella, Shigella, E. coli* are of public health concern because they contribute to serious illness.

Personal Contamination of Food Products

Body location

- Composition of normal microbial flora varies depending on body area. Face, neck, hands and hair contain higher proportion of transient microorganisms and bacterial density. Exposed areas of body are more vulnerable to contamination from environmental sources.

Age

- Microbial population changes as person matures. This trend is especially true for adolescents entering puberty. Produce large quantities of lipids known as sebum, which promotes formation of acne caused by *Propionibacterium acnes*.

Hair

- Because of density and oil production, hair on scalp enhances growth of *S. aureus*.

pH

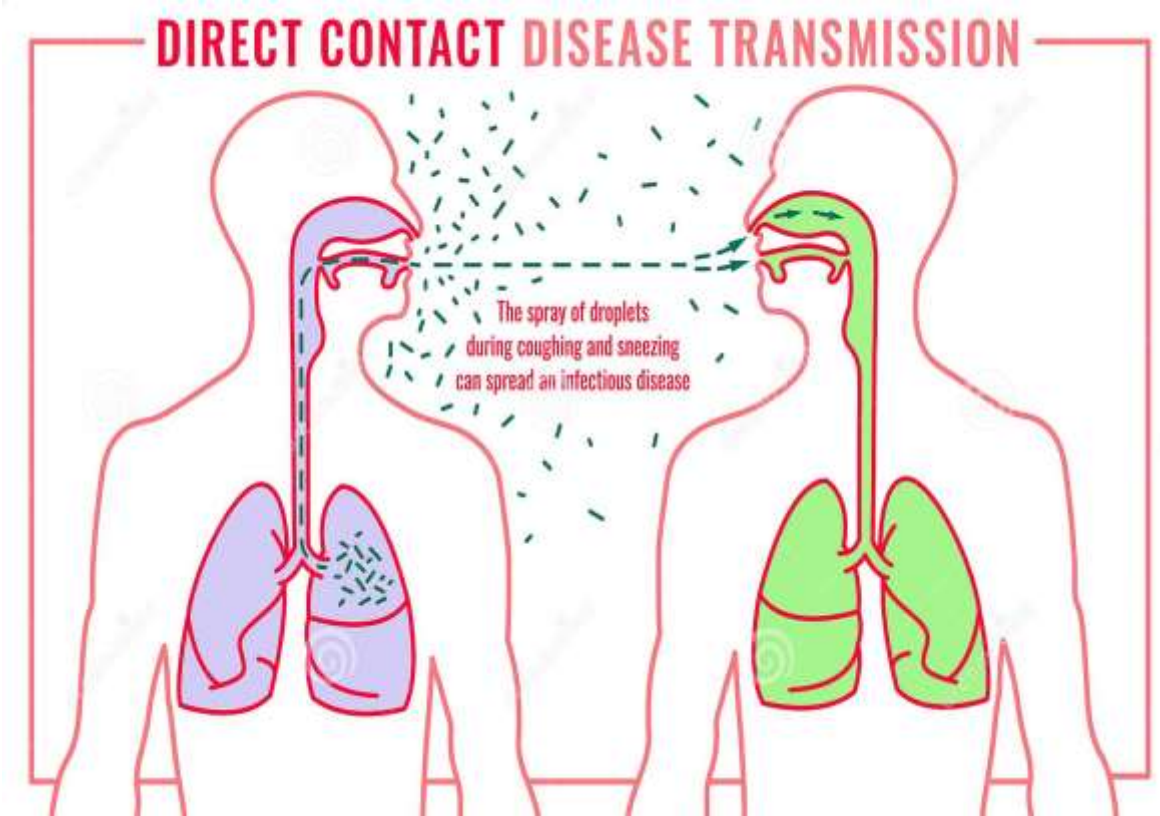
- pH of skin is affected through secretion of lactic acid from sweat glands, bacterial production of fatty acids, and diffusion of carbon dioxide through skin. Approx. pH (5.5) for skin is more selective against transient microorganisms than it is against the resident flora.

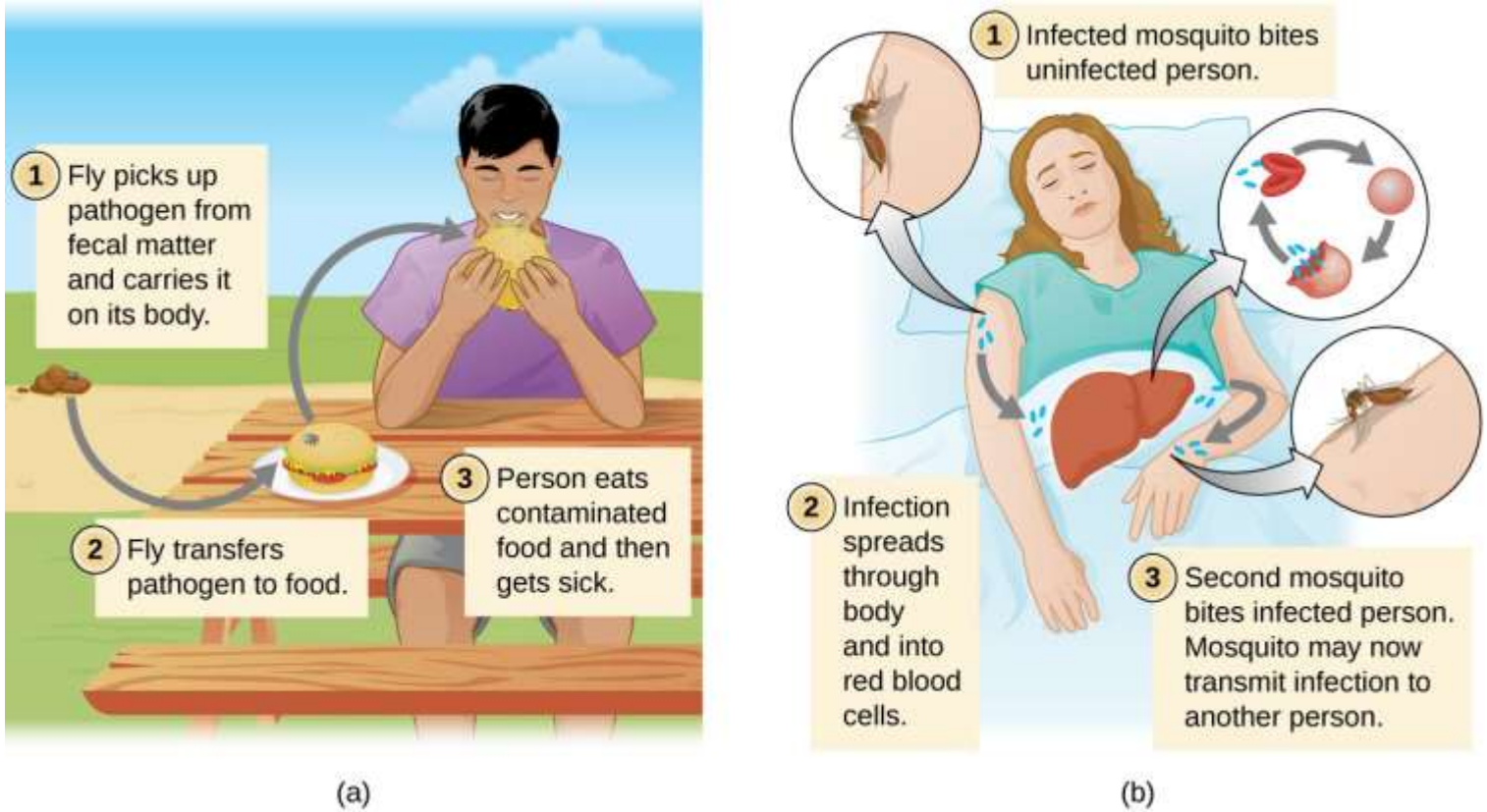
Nutrients

- Perspiration contains water soluble nutrients (inorganic ions and some acids), whereas; sebum contains lipid (oil)-soluble materials such as triglycerides, esters, and cholesterol

Methods of Disease Transmission

Direct transmission: Many diseases are transmitted through direct transfer of microorganisms to another person through close contact. Scarlet fever, influenza, pneumonia, smallpox, tuberculosis, typhoid fever and dysentery. Respiratory diseases may be transferred via atomized particles extruded from nose and mouth when a person talks, sneezes, or coughs. When these particles become attached to dust, they may remain suspended in air for an indefinite length of time. Other people become infected upon inhaling these particles.





Indirect transmission: **Host of an infectious disease may transfer organisms to vehicles such as water, food, and soil. Lifeless objects capable of transmitting infections are doorknobs, telephones, pencils, books, washroom fittings, clothing, money, and knives. Intestinal and respiratory diseases may be spread by indirect transmission. Wash basins should have foot-operated controls instead of hand-operated faucets, and doors should be self-closing.**

Precautions

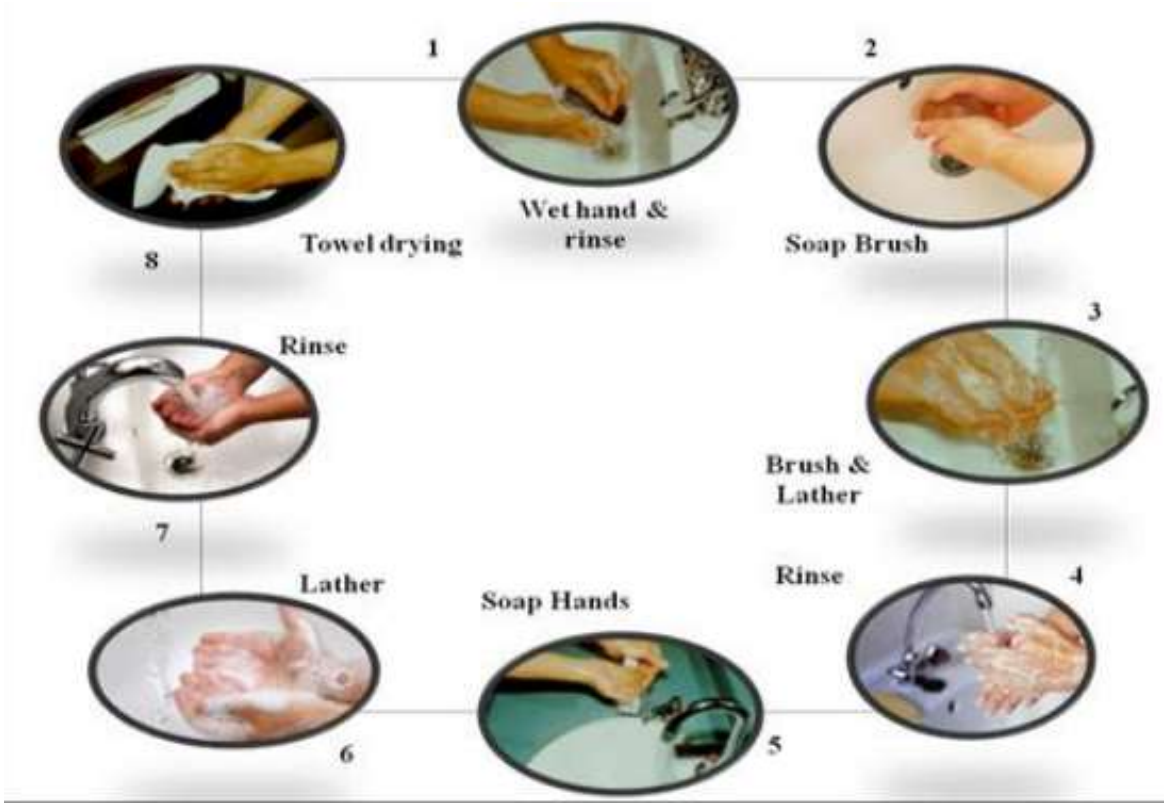
Hand Washing:

- Microorganisms found on hand surfaces may be transient or resident bacteria.
- Transient bacteria are picked up accidentally by food handlers and are transient in that they reside on hands only temporarily (e.g., *E. coli*).
- Residual microorganisms permanently reside on hand surfaces and are normal or resident microflora of skin (*Staphylococcus epidermidis*).
- First line of defense against disease is frequent and effective hand washing by food handlers.

Procedures for hand washing:

❑ Manual double hand washing method:

- ❖ Hand washing for 15 secs with soap and water, which act as emulsifying agents to solubilize grease and oils on hands, will remove transient bacteria.
- ❖ Increased friction through rubbing hands together or by using scrub brush with soap can reduce number of transient and resident bacteria than is done by quick hand washing.
- ❖ Hand washing and drying efficacy against resident flora ranges from 35-60%.
- ❖ All hand washing agents, including water are effective when hands are dried with paper towels.



Procedures for hand washing:

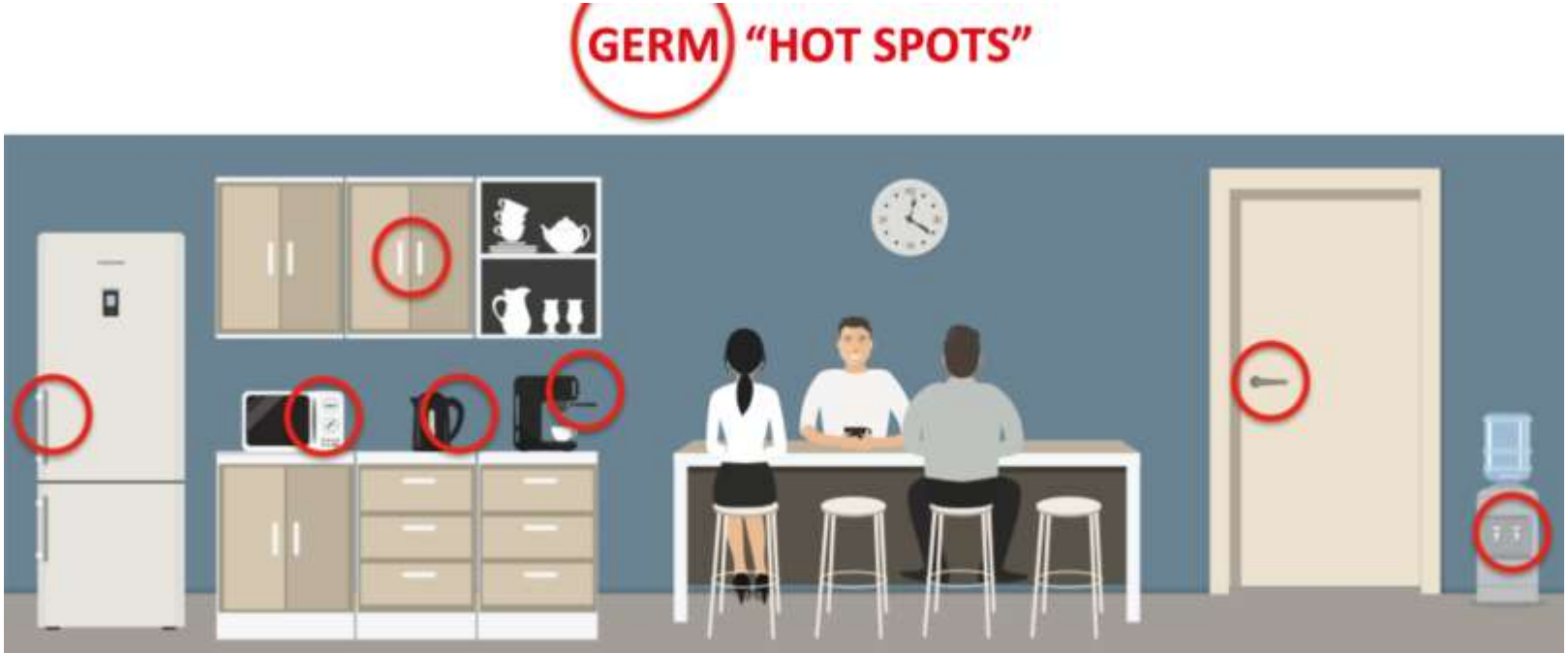
❑ Mechanized hand washers:

- ❖ Workers enter area and use the washing unit.
- ❖ This equipment is responsible for increased hand washing frequency by 300%.
- ❖ The user inserts hands into two cylinders, passing photo-optic sensor, which activates cleansing action.
- ❖ High pressure jet sprays within each cylinder spray a mixture of antimicrobial cleansing solution and water on hands followed by portable water rinse.
- ❖ This 10 sec cycle is 60% more effective at removing pathogenic bacteria from hands than average manual hand washing and reduced water cost.

- Disinfection steps after hand washing: Alcohol hand rub, gel, or rinse sanitizers that contain at least 60% alcohol have been incorporated as disinfection step after washing hands with soap and water.
- Alcohol-based instant hand sanitizers used after hand washing, provide an additional 10-100 fold reduction.
- Instant hand sanitizers (protective creams and lotions) is considered when washing is not possible.
- Ethanol is more effective for viruses than iso-propanol; however, both alcohols are effective for the destruction of bacteria, fungi, and viruses.
- Most effective regimen for antimicrobial control is combination of an antibacterial soap hand wash followed by an alcohol gel application.
- Caution is necessary when alcohol is applied because it is flammable.
- Other antiseptic hand washing compounds include iodine and iodophors (complexes of iodine with a carrier such as poly-vinyl-pyrrolidone).
- Gloves should be put on after hands are washed and dried.
- If hands are not dry, residual moisture forms an incubation environment for bacteria under gloves.

Requirements for Hygienic Practices

Supervisors and managers should set an example for employees by their own high levels of hygiene and good health while conveying importance of these practices to employees. They should provide proper laundry facilities for maintenance of cleanliness through clean dressing rooms, services, and welfare facilities. Management should require employees to have pre-employment physical examination to verify that they are in good physical, mental, and emotional health.



- **Practices should be conducted to ensure personal hygiene:**
- Physical health should be maintained through proper nutrition and physical cleanliness.
- Illness should be reported to employer before working with food so that work adjustments can be made to protect food from employee's illness or disease.
- Hygienic work habits to eliminate potential food contamination.
- During work shift, hands should be washed after using toilet; handling garbage or other soiled materials; handling uncooked muscle foods, egg products, or dairy products; handling money; smoking; coughing; or sneezing.
- Personal cleanliness: Daily bathing and use of deodorants, washing hair at least twice a week, cleaning fingernails daily and wearing clean uniforms.
- Employee hands should not touch food service equipment and utensils.
- Disposable gloves should be used when contact is necessary.
- Rules such as "no smoking" should be followed.

- **Employers should emphasize hygienic practices of employees :**

Employees should be provided training in food handling and personal hygiene	Regular inspection of employees and their work habits should be conducted
Incentives for superior hygiene and sanitary practices should be provided	Food handlers to be responsible for their own health and personal cleanliness

Sanitary Food Handling

1. A protective sanitation barrier between food and sources of contamination should be provided during food handling.
2. Barriers include hairnets, disposable gloves, mouth guards, sneeze guards and food packaging and containers.
3. Food processing and food service firms should protect their employees and consumers from workers with diseases or other microorganisms of public health concern that can affect sanitary quality of food.
4. Local health codes prohibit employees having communicable diseases or those who are carriers of such diseases from handling foods or participating in activities that may result in contamination of food.
5. Although some areas no longer require health cards because of the expense involved, many local health departments require all employees who handle food to be examined by physician who will issue a health card only to healthy individuals.

Absence of communicable diseases should be verified through county health card/physician's report

Applicants should not exhibit evidence of sanitary hazard such as open sores/presence of excessive skin infections

Applicants having respiratory problems should not handle food

Applicants should be clean, neatly groomed and should wear clothing free of unpleasant odour

Applicants should successfully complete sanitation course and examination

Selection of employees should be predicated ……..


Employee Responsibilities
Required personal hygiene
Facilities
Employee supervision

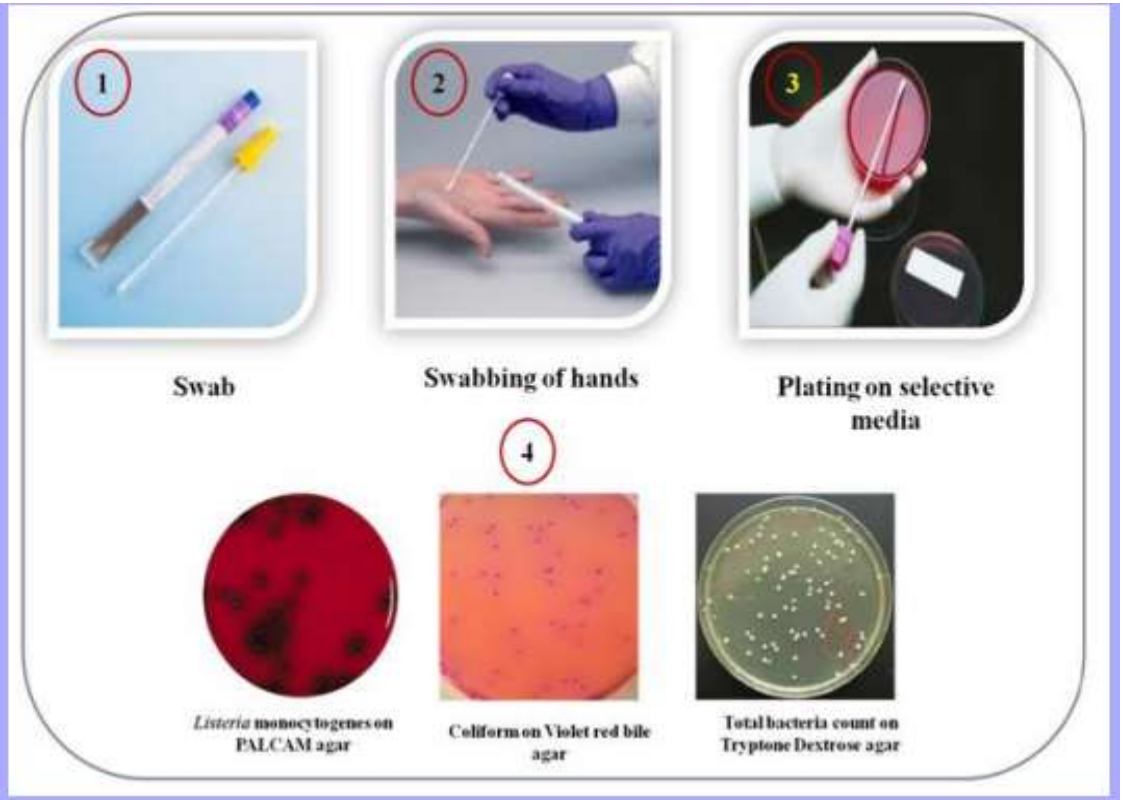
- Employees should maintain healthy condition to reduce respiratory/gastrointestinal disorders.
- Injuries, including cuts, burns, boils, and skin eruptions should be reported to employer.
- Abnormal conditions, such as respiratory system complications (e.g., head cold, sinus infection, and bronchial and lung disorder) and intestinal disorders should be reported to employer.
- Personal cleanliness includes daily bathing, hair washing at least twice a week, daily changing of undergarments and maintenance of clean fingernails.
- Scratching head or other body parts should be stopped.
- Mouth and nose should be covered during coughing/sneezing.
- Hands should be washed after visiting toilet, using hand kerchief, smoking, handling soiled articles, or handling money.
- Rules related to use of tobacco should be enforced.

Training

1. Dairy plants must have an adequate program to monitor and control training programs and maintain appropriate documentation.
2. Objective of personnel training program must be to ensure safe food handling practices.
3. Personnel training program must provide ongoing training for production personnel.
4. Procedure to be developed to verify effectiveness of training program.
5. Production personnel must be trained to understand critical elements for which they are responsible, what critical limits are, importance of monitoring limits, and actions they must take if limits are not met.
6. Ongoing training in personal hygiene and hygienic handling of food must be provided to every food handler, training in personal hygiene and hygienic handling of food must be provided to all persons entering food handling areas.

Hygiene Monitoring

1. Microbiological methods are available to monitor total counts on items of plant, most methods require establishment of laboratory designed to handle live cultures.
2. Cleanliness can be assessed in microbiological laboratory by taking washings from hands by means of sterile cotton-wool pads and inoculating washings on to nutrient media.



Scale of marks for judging results of bacterial examination are "excellent" is given to workers from whose hands washings show <2000, "good"- 2000 to 5000 bacteria, "fair" - 5000 to 10 000 CFU/ ml. and >10,000 is "bad". If gas appears in fermentation liquid a "bad" mark is given independently of total number of bacteria.


EXIT

1. Hygiene problems in equipment are caused when micro-organisms attach to surfaces, survive and later become detached thus contaminating and reducing quality of product.
2. Constructions that cause problems (soil, product debris and micro-organisms can accumulate, e.g. dead ends, sharp corners and low-quality seals and joints.
3. Even if ‘dead’ areas have been ‘designed out’, some product will attach to equipment surfaces, despite possibility of fast-moving liquids.
4. Microbes may also penetrate through very small leaks. They can pass through microscopic openings very rapidly and that pressure differences may retard passage, even if pressure-difference is as high as 0.5 bar.
5. Motile bacteria may propel themselves against flow of liquid through leak.
6. Good hygienic design of food processing equipment protects product from contamination with substances harmful to consumer health and provides access for cleaning, maintenance and inspection.

General aspects of sanitary construction and design of food equipment

Food product contact surface is a surface in "direct contact with food residue, or where food residue can drip, drain, diffuse, or be drawn". These surfaces directly result in food product contamination, rigid sanitary design criteria must be met.

Non-product contact surfaces are those that are part of equipment (legs, supports, housings) that do not directly contact food. As contamination of these surfaces can cause indirect contamination of food product, so cannot be ignored with regard to sanitary design.

Food product contact surfaces:

Should be:

- Smooth
- Impervious
- Free of cracks and crevices
- Nonporous
- Nonabsorbent
- Non-Contaminating
- Nonreactive
- Corrosion Resistant
- Durable and Maintenance Free
- Nontoxic
- Cleanable

Surface texture and/ or finish:

- Final surface to be smooth, durable, free of cracks and crevices and meets other sanitary design requirements.
- Sanitary Standards require that ground or polished stainless steel surfaces meet ground surface, and unpolished surfaces meet a No. 2B or mill finish.
- 3-A Sanitary Standards development group has recently adopted an industry recognized method for determining an acceptable food contact surface **termed roughness average or Ra value**.
- Ra is determined using sensitive instrument (termed a profilometer) which employs diamond tipped stylus to measure peaks and valleys in a relatively smooth surface.

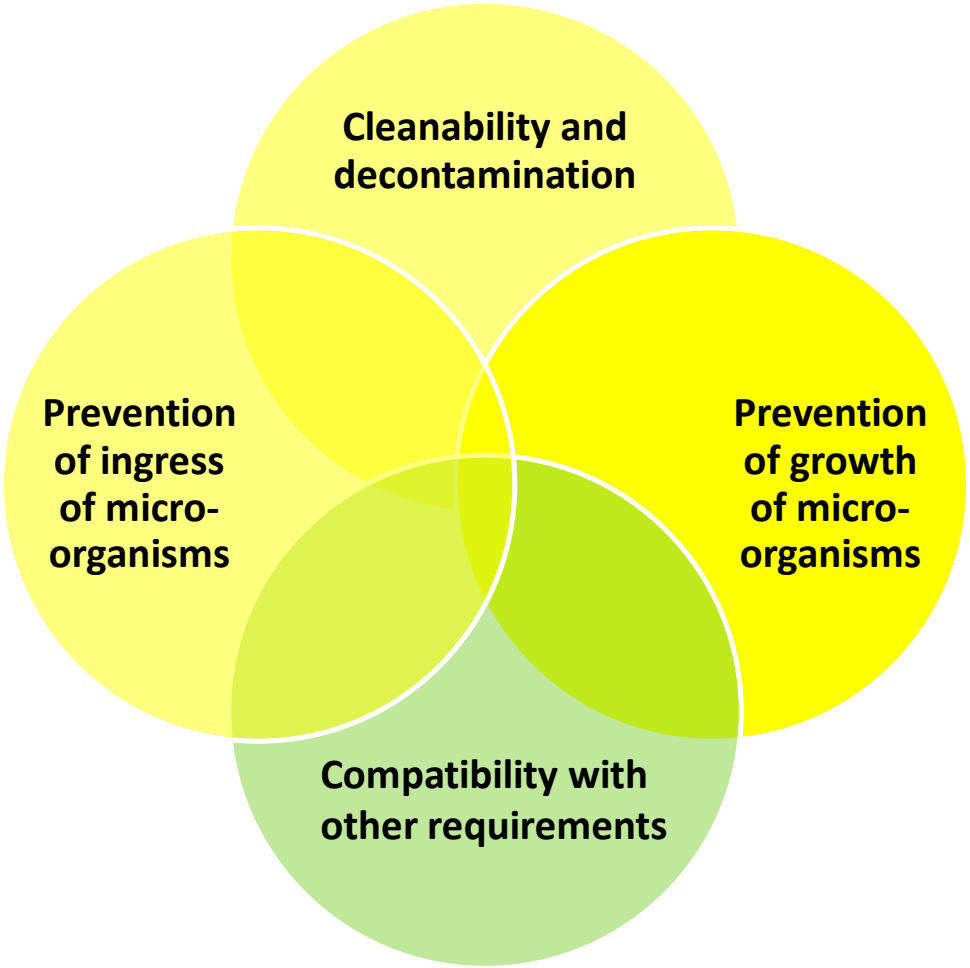
Construction and fabrication:

- Food equipment should be designed and fabricated in such a way that all food contact surfaces are free of sharp corners and crevices.
- Construction of all food handling or processing equipment should allow for easy disassembly for cleaning and inspection.
- Vessels, chambers, tanks should be self-draining.
- Piping systems (CIP) not designed for routine dis-assembly must be sloped to drain.

Internal angles:

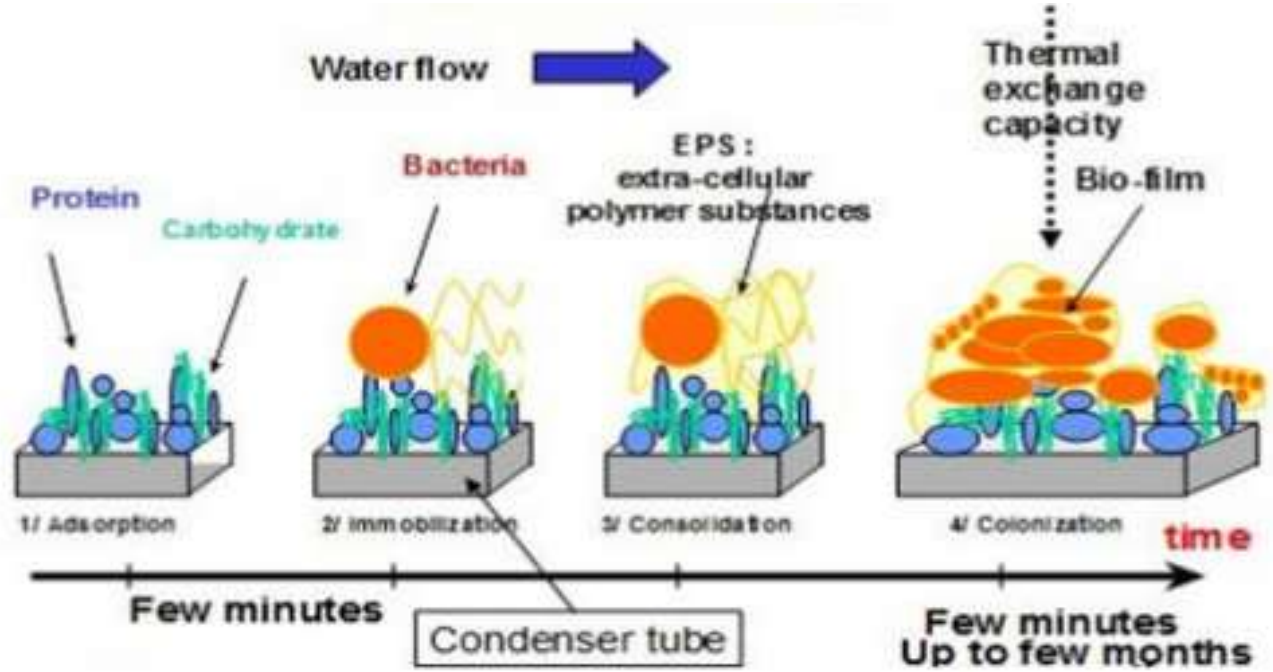
- Internal angles should be rounded with defined radii.
- Equipment standards specify appropriate radii for specific equipment applications and components. Eg., radii requirements stated in 3A sanitary standards

Functional requirements of equipments

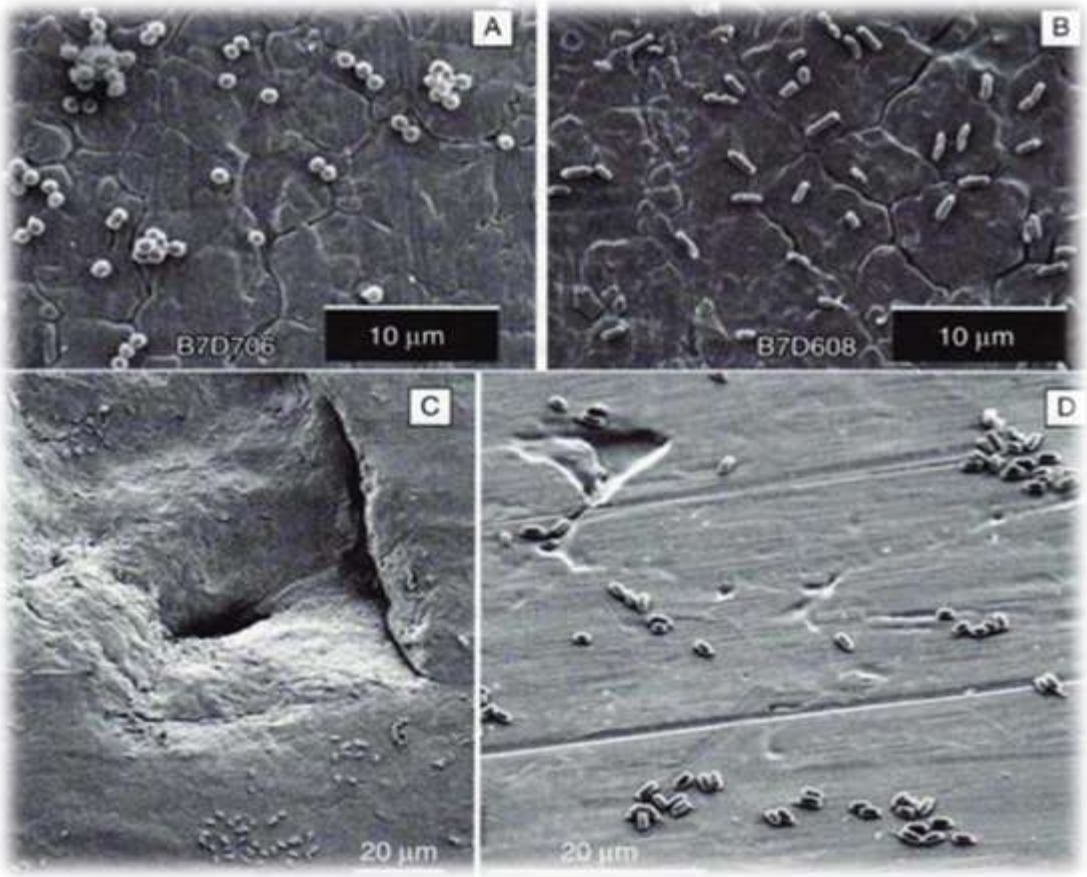


Biofilm on dairy equipments:

- Biofilms form in two stages: first, an electrostatic attraction occurs between surface and microbe.
- Next phase occurs when organism forms an extracellular polysaccharide, which firmly attaches cell to surface.
- Cell then multiplies, forming micro-colonies and biofilm.
- Biofilm development may take place on any type of surface.
- Difficult to remove during cleaning operations.
- Microorganisms difficult to remove: *S. aureus* and *L. monocytogenes*.
- Heat treatment is more effective than application of chemical sanitizers.



Klebsiella pneumoniae, Legionella pneumophila, L. monocytogenes, Salmonella typhimurium, S. aureus **and** ***Yersinia enterocolitica*** **form biofilms, even under presence of disinfectants. Thermophile (*Streptococcus thermophilus*) can form biofilm in cooling section of milk pasteurizer within 5 h, resulting in contamination of pasteurized product (up to 10^6 cells/mL). On metal and stainless steel surfaces, biofilms may enhance corrosion, leading to development of microscopic holes. Also affect heat-transfer in heat exchanger.**



Biofilm formation in milk processing environments

- Biofilms are difficult to remove than ordinary soil.
- If cleaning is not capable of removing biofilm completely, decontamination of surface by either heat/chemicals may fail, since biofilm dramatically increases resistance of embedded organisms.
- **Acidic quarternary ammonium compounds, chlorine dioxide and peracetic acid**: Most effective sanitizers for eliminating attached cells.
- Least effective: **chlorine, iodophors and neutral quaternary ammonium compounds.**
- When attached organisms were exposed to cleaning compounds prior to treatment with sanitizers, bacteria were readily inactivated.

ISO International Organization for Standardization

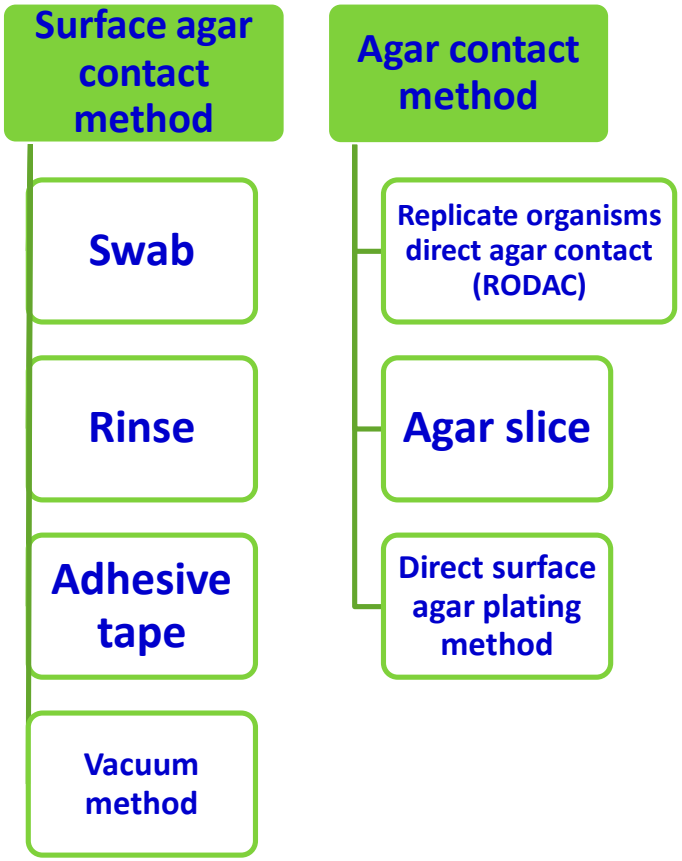
CODEX International Food Standards

International Standard Organization (ISO), International Dairy Federation (IDF) and Codex Alimentarius Commission (CAC) are generally involved in development of equipment hygiene standards.

Equipment Hygiene Monitoring

By sampling surfaces it can be possible to prevent contamination of milk and milk products, helps in tracing source of contamination and optimization of cleaning process. Quantitative estimation of microorganisms from surfaces is very difficult because of strong microbial adherence.

Surface hygiene monitoring methods



Swab contact method:

- Cotton swab moistened with quarter strength ringers solution is applied over a known area of equipment and in process all micro-organisms adhered to surface of equipments are transferred to swab.
- After proper mixing, swab suspension is diluted and plated on different agar plates containing tryptone dextrose agar, violet red bile agar and potato dextrose agar etc. followed by incubation at respective temperature - time combination.
- Counts of colony developed in respective plates were counted.
- Two specified areas of 50 cm^2 are randomly selected on test equipment.

Method is modified and simplified by combining with membrane filtration technique and place it in enriched broth for qualitative identification of microorganisms. Swab suspension is filtered through cellulose acetate filter (0.45 µm) and then filter membrane is layered on selective medium.

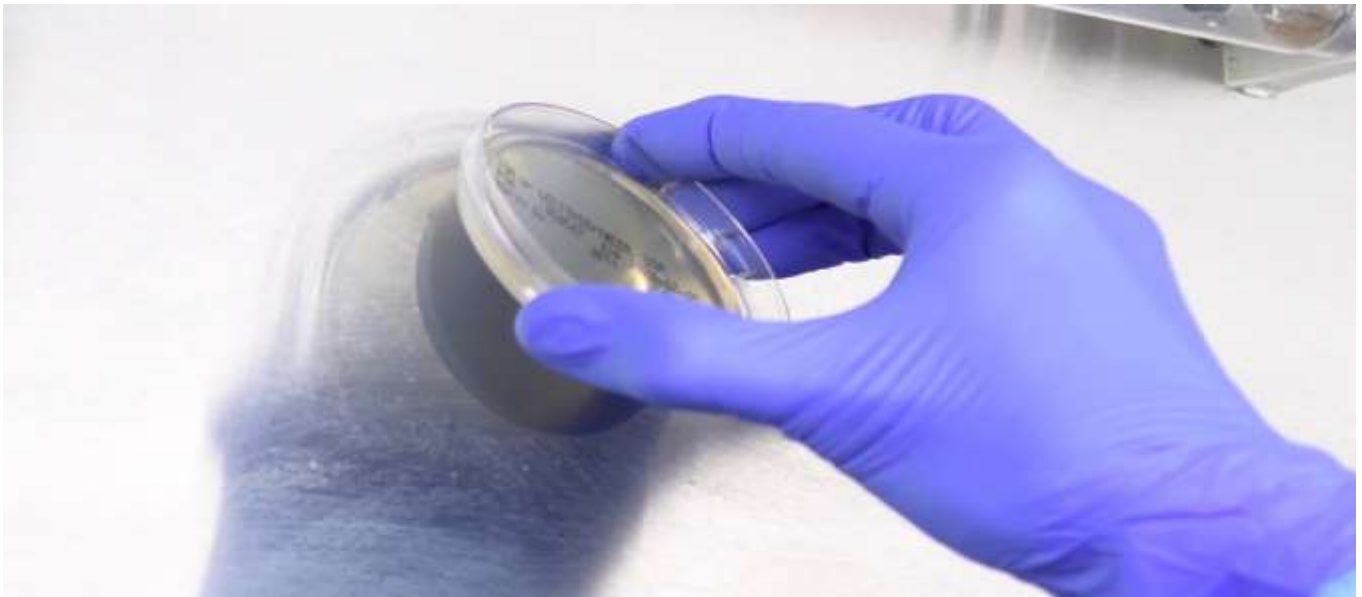
Swab technique for qualitative identification of hygiene

Surface rinse method:

- Effective and useful method for enumeration of microorganisms equipment surface.
- Used for microbiological examination of bottles, cans, farm dairy equipment and pipelines of the processing machines.
- Standard amount of 20 mL for milk bottles and 500 mL for milk cans, of sterile quarter strength ringer's solution is poured into containers, mixed or shaken several times so that diluents or rinse comes in contact with whole surface of the container followed by colony count of rinse is determined on specific media.
- Moderate recovery (70%) and good repeatability.

RODAC method:

- In this method, plastic strips of specific size (25cm^2) are filled enough molten agar medium to allow a convex surface to form.
- After solidification of medium, agar surface is gently pressed against test surface of equipment, removed and covered with lid and subsequently incubated.
- Test is not suitable for heavily contaminated surfaces.
- Drawback: Cannot distinguish single surface bacteria and clusters of microorganisms.
- Maximum accurate count is limited to 200 colonies/ plate.
- Recovery is very high (80%) and reproducibility is excellent.



Agar slice method:

- Specified molten agar medium is filled in sterile syringe and is allowed to solidify.
- Solidified medium is pushed out and allowed to make contact with test surface.
- Portion of agar that comes in contact with surface is sliced off and transferred to petri dish or subsequent incubation and colonies are counted.
- Recovery with this method is 72-75%.

Direct surface agar plating method:

- Molten agar medium directly poured onto surface.
- Due to direct contact of surface to medium, colonies are developed after appropriate incubation and counted.
- Recovery is fairly high (80%).
- Drawbacks: Does not work with pipelines and cans.

Microbiological criteria for dairy equipment:

Grade	Total bacterial count/ 100 cm^2	
	For storage of raw products	For storage of pasteurized products
Good	< 200	< 10
Satisfactory	200 - < 1000	10-50
Unsatisfactory	1000 – 10000	>50
Heavily contaminated	>10000	-

Where large surfaces are available the area swabbed (or rinsed or contacted) is 900 cm^2

Microbiological criteria for sanitary condition of dairy equipment

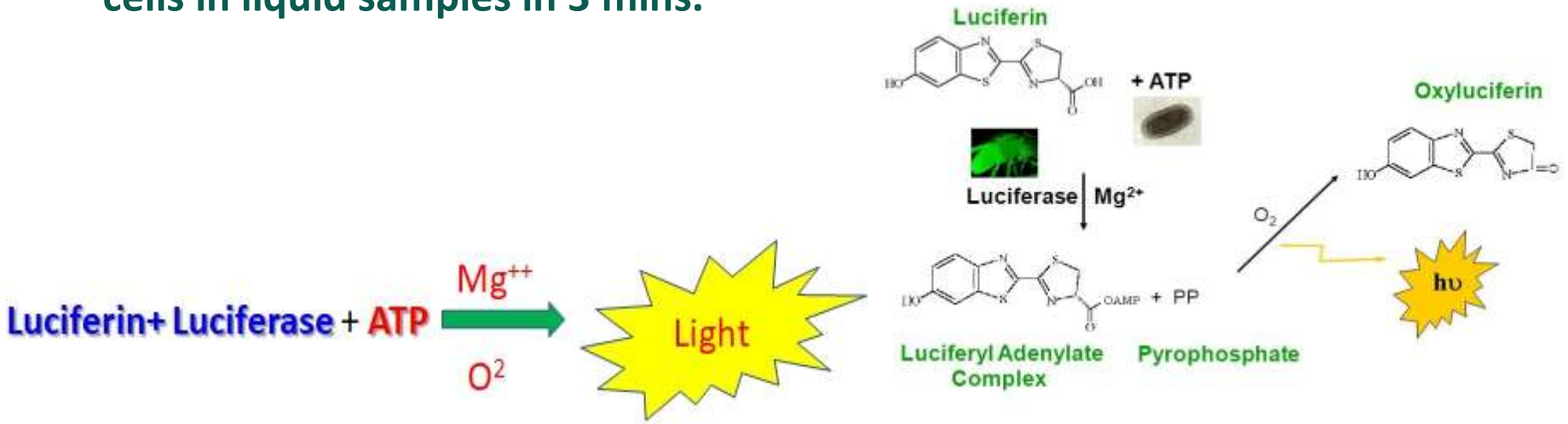
Bacteriological standards for sterility of dairy equipment

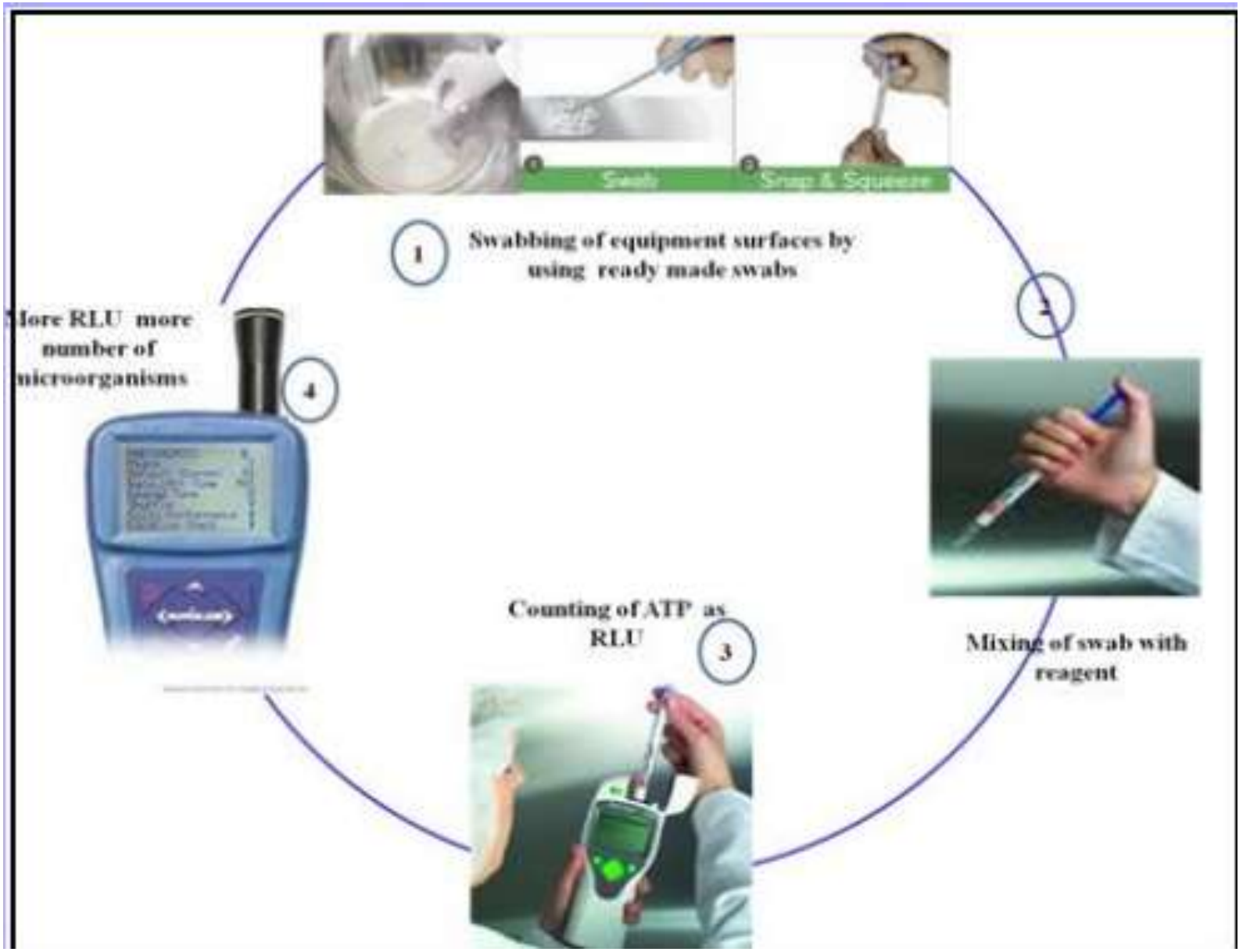
Equipment	Standards for satisfactory sterility	
	Max. SPC/ l capacity (Rinse method)	Max. SPC/ 900 cm^2 of surface (Swab Method)
Milk can/ pail/ milk bottle	1000	-
Milk receiving tank	-	5000
Weighing bowl/pan	-	5000
Storage/ holding/ transport tanks	-	5000
Batch pasteurizer	-	5000
Plate heat exchanger	-	5000
Surface cooler	-	5000
Cotton filter cloth evaporator	-	5000
Roller dryer	-	5000
Bottle filler	25000*	
HTST plate pasteurizer	25000*	
Homogenizer	25000*	
Cream separator/clarifier	25000*	
Spray dryer	25000*	
Ice cream freezer	25000*	
Walls, floors etc.	25000*	
Milk crates	25000*	

*Circulation method, SPC of first liter of rinse coming out

ATP bioluminescence test:

- ATP bioluminescence is biochemical which measures presence of adenosine triphosphate (ATP) by its reaction with luciferin-luciferase complex.
- Estimation of microbial load of food sample, equipment surfaces and water sample.
- Bioluminescent reaction requires ATP, luciferin, and firefly luciferase - an enzyme that produces light in the tail of the firefly.
- During reaction, luciferin is oxidized and emits light.
- A luminometer measures light produced, which is proportional to amount of ATP present in sample.
- ATP content of sample can be correlated with number of microorganisms present because all microbial cells have a specific amount of ATP.
- An automated luminometer can detect presence of yeast, mold, or bacterial cells in liquid samples in 3 mins.





Step wise procedure for ATP bioluminescence assay

- A computer-interfaced luminometer employs customized software, a printer, and an automatic sampler, can analyze samples with a sensitivity of one microorganism per 200 mL.
- Use of this method has increased because ATP bioluminescence test can release product in less than 24 h.
- Advantage of this test is that ATP from tissue exudates can be detected.
- This test identifies dirty equipment.
- Results were expressed as log10 **Relative Light Unit (RLU)** released by total ATP.
- Higher the amount of ATP on surface/food samples, higher the light output expressed in RLU.
- According to recommendations of the ATP-bioluminescence equipment manufacturer, measurements lower than 150 RLU were considered clean, from 151 to 300 RLU were considered suspect, and values higher than 301 RLU were considered inadequate hygienic conditions.

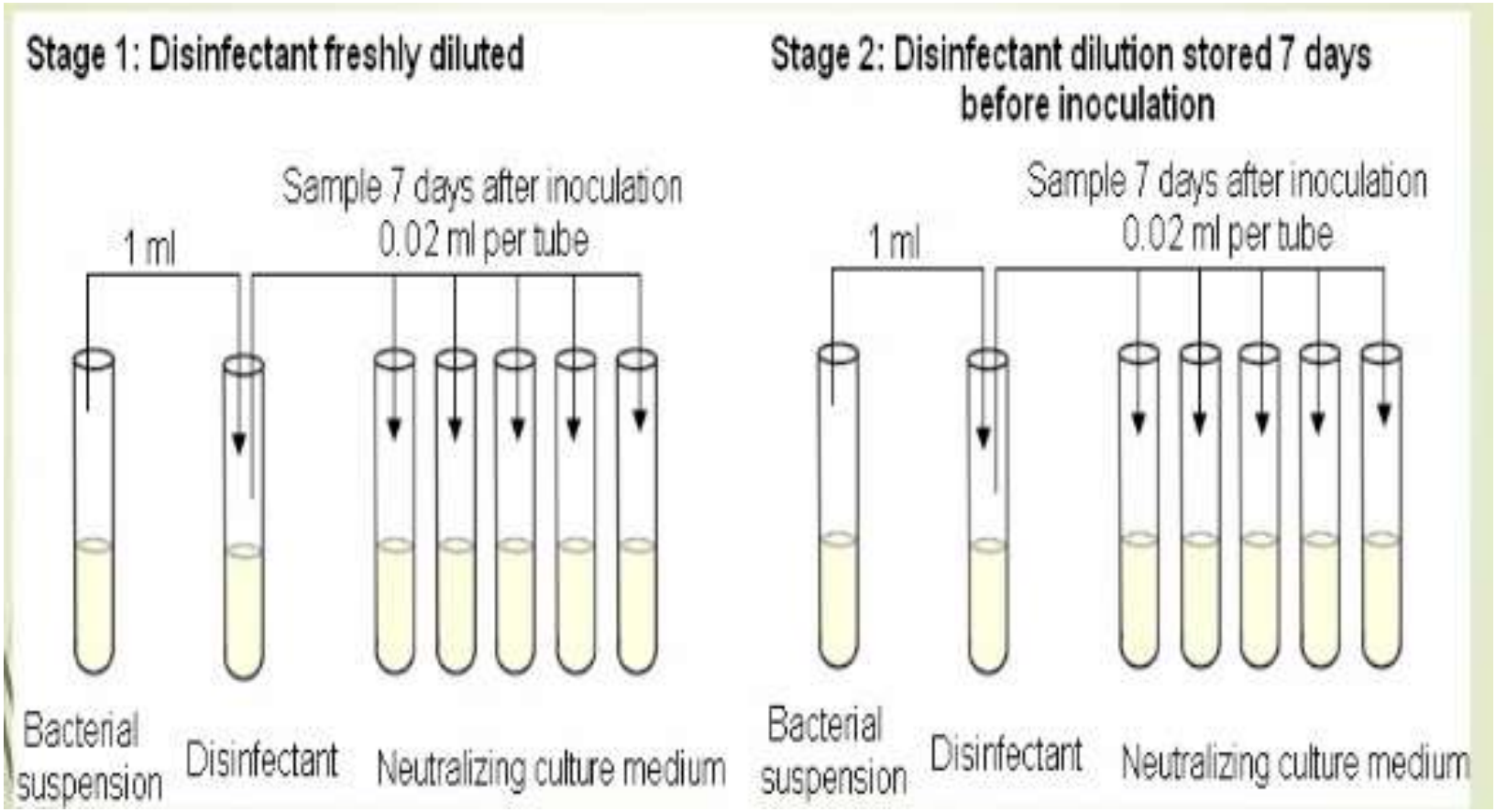
Assessment of Efficacy of Detergent and Sanitizer by Capacity and Suspension Test

Capacity test

- Involves taking definite quantity of test solution (sanitizer) & definite number of cells.
- Action of sanitizer depends on its concentration and period of contact with organism.
- Shorter period to destroy test organism in particular concentration, better would be efficiency of detergent/ sanitizer.
- Based on enumeration of survivors of test culture after definite period of contact with sanitizer.

Procedure

- Take 20 mL sanitizer, inoculate 1 mL inoculum (washed suspension of culture O.D.0.3)
- After 1 min take out 0.1 mL of mixture & transfer in 5 mL nutrient broth
- Add 0.1 mL inoculums immediately so that amount remain same, take 10 increments
- Incubate all samples and one positive blank (from 21 mL add 1 mL in N. B.) at 37 C for 48 hrs
- Observe growth in nutrient broth tubes, plating and count colonies.


Stage 1: Disinfectant freshly diluted
Sample 7 days after inoculation
0.02 ml per tube
1 ml
Bacterial suspension
Disinfectant
Neutralizing culture medium
Stage 2: Disinfectant dilution stored 7 days before inoculation
Sample 7 days after inoculation
0.02 ml per tube
1 ml
Bacterial suspension
Disinfectant
Neutralizing culture medium

Suspension test

- Sample of bacterial culture is suspended into disinfectant solution and after exposure it is verified by subculture whether this inoculum is killed or not.
- There are different kinds of suspension tests: Qualitative suspension tests, the test for the determination of the phenol coefficient and quantitative suspension tests.
- Loopful of bacterial suspension was brought into contact with disinfectant and again loopful of this mixture was cultured for surviving organisms.
- Results were expressed as ‘growth’ or ‘no growth’.
- In quantitative methods, number of surviving organisms is counted and compared to original inoculum size.
- By subtracting the logarithm of the former from the logarithm of latter, the decimal log reduction or microbicidal effect (ME) is obtained.
- An ME of 1 equals to killing of 90% of initial number of bacteria, an ME of 2 means 99% killed.
- Generally accepted requirement is an ME that equals or is greater than 5: at least 99.999% of germs are killed.

Procedure

- ❑ Take 100 mL of disinfectant and inoculate 1 mL inoculums.
- ❑ From step 1, take 1 mL and inoculate in petriplate after 0, 1, 2, 5, 10, 15 mins.
- ❑ Incubate plate at 37 C for 48 hrs and count colonies.