Dr. Mohanad Faris Abdulhameed
Public Health Department
College of Veterinary Medicine
University of Basrah
Class-Meat Hygiene-Year Five

Slaughterhouse and sanitation

Important of establishment of abattoir

1- The overall number and siting of abattoirs in any country should be geared closely to the demands of livestock production.
2- This should be balanced with a desire to ensure animal transport times are kept to a minimum and with a requirement for facilities to deal with on-farm emergency slaughter animals.
3- Has a role in surveillance, control, and eradication of diseases of animal health importance, as well as control, reduction, and prevention of foodborne hazards of public health importance

What facilities should be provided for an abattoir?

1. Mains water and electricity supply (daily usage of water can be in excess of 1000 l/tonne dressed carcase weight for cattle, 3000 for sheep).
2. Mains sewerage.
3. Contiguity with uncongested transport systems, close to motorway access.
4. Proximity with public transport, for employees.
5. Proximity to supply of varied labour.
6. Freedom from pollution from other industries' odours, dust, smoke, ash, etc.
7. Ability to separate 'clean' and 'dirty' areas and access.
8. Remoteness from local housing and other development to avoid complaints about noise and smell.
9. Good availability of stock nearby.
10. Ground suitable for good foundations including piling and freedom from flooding.
11. Sufficient size for possible future expansion.

Lairage

Importance of the lairage: after transportation, animals are usually kept in lairage (holding pens) for a period before being slaughtered. One purpose of lairage is to maintain a reserve of animals so that the processing line in the abattoir can operate at a constant speed and not be affected by variation in the rate of delivery of livestock. When lairage conditions are good it also gives animals a chance to rest and drink.

Facilities at the lairage

Water must be made available to animals at all times in the lairage. The facility provided must be suitable for the type and numbers of livestock. Forage and feeding facilities must be made available if animals are to be kept in the lairage for more than 12 hours. A suitable sized store is therefore required for the storage of feed and forage and of bedding material where this is used. An isolation pen, with solid walls and separate drainage, must be available for sick or 'suspect' animals. *Toilet* and *hand-washing facilities* must be provided in the vicinity of the lairage. *Boot-washing equipment* is an essential component for farmers, buyers and lairage staff. Points for connection for a power hose should be placed conveniently, so that all parts of the lairage can be reached by a sufficient supply of water for cleansing; an adequate estimate is 500l per adult bovine slaughtered. Whatever system of lairage is adopted, special emphasis must be placed on ease of cleansing, comfort for the animals and ease of handling them.

Slaughter hall

The transfer of animals from lairage to slaughter hall is easy if the abattoir is well designed. If an upper kill floor is used and the site is on a slope, the animals can be walked directly on the slaughter floor; using a ramp as necessary. Cattle and sheep can readily be driven up a ramp as steep as 1 in 6, though the ramp should be provided with battens and a catwalk. The size and type of slaughter hall depends upon the species to be slaughter, the maximum possible capacity and the slaughter and dressing systems to be adopted. Sufficient space must be provided to allow hygienic processing, to avoid cross-contamination. Good lighting and ventilation must be provided.

Slaughter hall construction:

1- Stunning area
2- Bleeding area
3- Cattle carcase dressing
4- On-the-rail dressing
5- Intermittent powered system
6- Gravity rail system
7- Singeing and scraping
8- Refrigeration accommodation
9- Detained meat room

10- Condemned meat room

11- Gut and tripe room

12- Hide and skin store

13- Red offal room

14- The edible fat room

15- Cutting rooms

16- Equipment wash

17- Fresh meat dispatch area

18- Veterinary office

19- General amenities for personnel

Rigor mortis

A relaxed muscle is flexible and myosin and actin filaments can slide past one another largely unhindered by interactions between myosin and actin. As individual muscle fibers become exhausted of supplies of energy they lose extensibility and enter rigor. The term rigor mortis refers to the muscle stiffness that occurs after all muscle fibers enter rigor. The main biochemical events in muscle related to the onset of rigor mortis can be summarized as:

1)Depletion of myoglobin-bound oxygen after death of the animal and cessation of mitochondrial respiration.

2)Shift from aerobic to anaerobic metabolism. The rate and extend of glycolysis in combination with external cooling will lead the muscle through different combinations of pH and temperature.

3)Disappearance of creatine phosphate soon time after death.

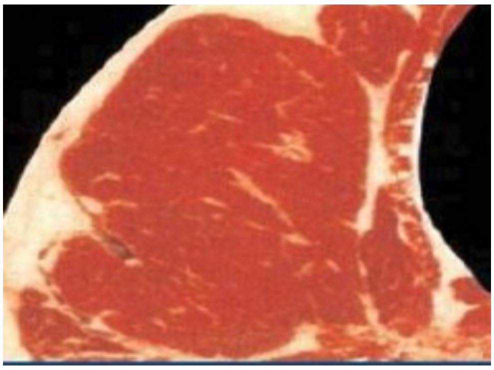
4)Disappearance of ATP, which begins after the creatine phosphate has declined.

5)Increase in free Ca^{2+} in sarcoplasm.

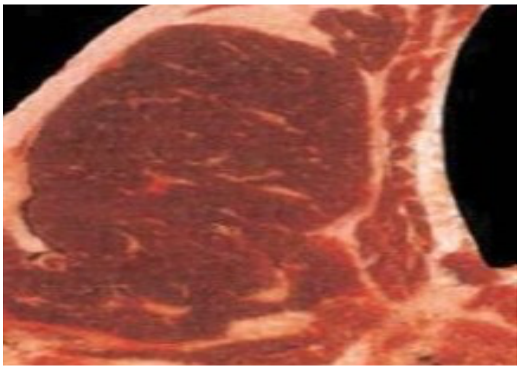
6)Formation of cross-links between myosin S-1 heads and actin resulting in actomyosin. The muscle becomes stiff and looses elasticity.

Moving the animals from the stable or farm to stunning and slaughtering

A long-term state of stress influences the quality of beef because it results in a high ultimate pH, causing dark, firm, dry meat (DFD or dark-cutting meat, the ultimate being pH 6.0 or higher) in some muscles. Muscle glycogen is mobilized by adrenalin (mental stress) and/or free calcium (physical stress causes free calcium levels to remain high and trigger the contraction). The combination of mental stress and physical exercise results in the fastest reduction of muscle glycogen. In long-term stress situations glycogen is used while the animal is still alive, but in non-stress situations only prolonged starving lowers the muscle glycogen level. The resting level of glycogen in bovine muscles, given as glucose, is about 100 mmol/kg muscle (1.8%). The long-term rate of glycogen depletion in stress is usually not higher than about 10 mmol per kg. Studies have shown that the ultimate pH starts to stay at a higher level than about 5.5 when the glycogen level at stun is lower than about 50 – 60 mmol/kg. DFD properties can be identified when the glycogen content is about 40 mmol/kg (0.7%). By then the low glycogen content does not provide enough glucose for *post-mortem* lactate (and protons, i.e. lactic acid) formation and the ultimate pH stays high, 6.0 or higher. Glycogen is not resynthesized as long as stress-induced adrenalin is attached to its receptors.



Normal beef lean color



Dark, firm and dry beef lean color

Slaughter processing at the abattoir

1-Stunning

Beef animals are most usually moved to a stunning box for stunning. The stunning can also be carried out in an open area, but this would risk the occupational safety of the operator. In the stunning box, there should be head lifter to support the head and to prohibit sudden movements of the head during the stunning. The stunning is usually with a bolt device, either a penetrating bolt or concussion bolt; electrical stunning is very rare in modern slaughterhouses. In some countries, for religious reasons, no stunning is used, the killing of the animal is done just by bleeding.

2-Electrical stimulation

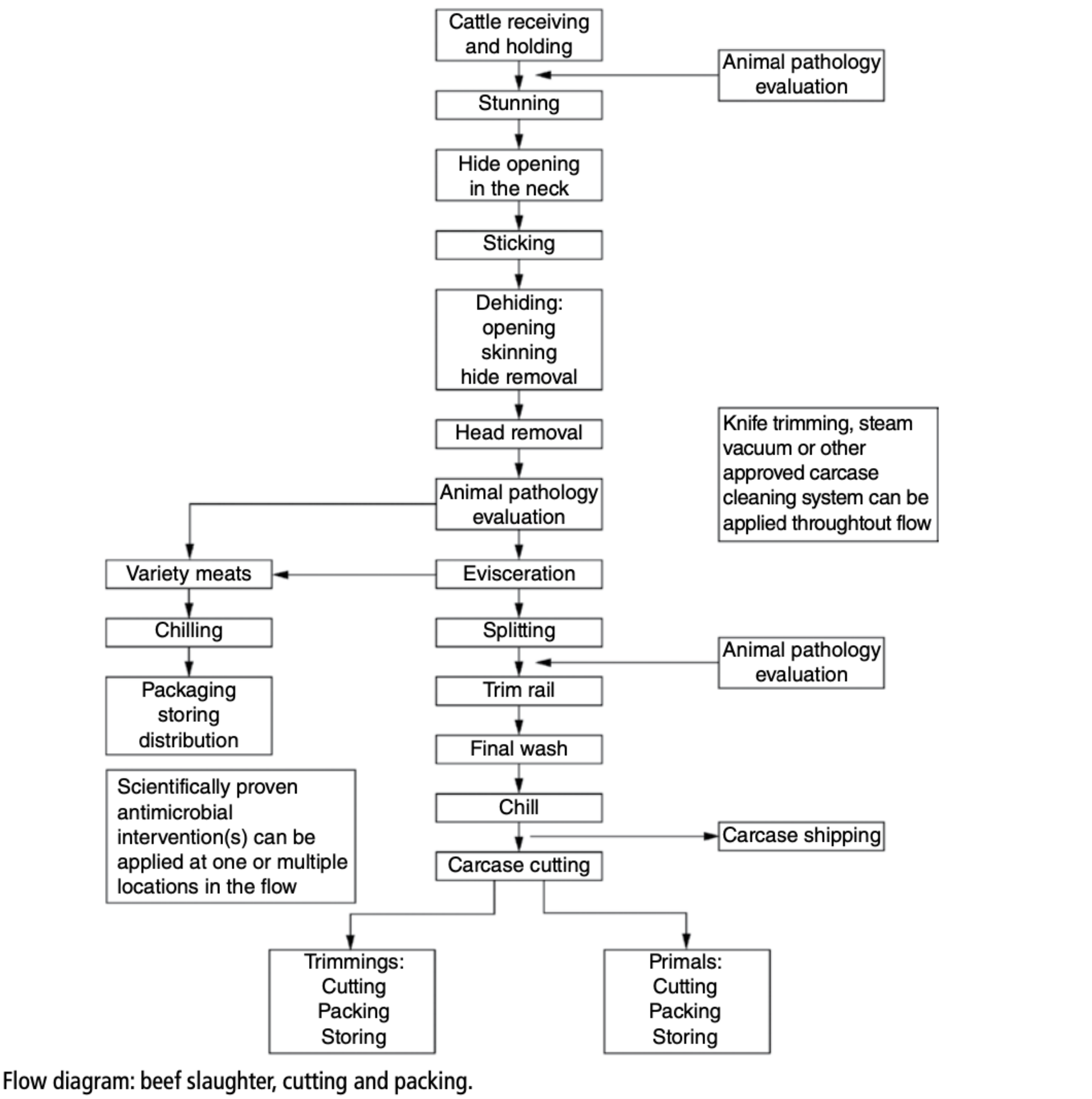
Once the animals have been stunned they are shackled to the rail and bled hanging from one hind leg on rail. The carcass may be electrically stimulated, either at low voltage (<80 V) or high voltage (around 300 V), to increase the rate of ATP consumption and pH fall to avoid cold shortening (Section 4.4.6). The alternating current (15 – 50 Hz) passes through the carcass, mimicking nervous stimulation, causing the pH to fall by 0.2–0.6pH units and the fibre membranes to be damaged to the extent that the pH fall will continue at double the normal rate. The electrode can be put individually into the nose, or in larger operations it is fixed, where carcasses slide on them when passing the stimulation zone. The rail is the ground electrode. Electrical stimulation may cause PSE-like quality if the cooling is slow.

3-Dehiding and opening the carcass

Due to the large size of beef animals, elevator platforms are used to facilitate the operations. After stimulation, the operators cut the horns with a pressure-driven horn remover, remove the hoofs and cut the rear end of rectum hide around the anus. The head is dehided and removed, and then the operator cuts the skin from anus hole to the trout with a dehiding knife. The genitals and udders are removed, and then the skin is party excised to help the mechanical dehiding. The oesophagus is closed by inserting a rubber ring, to avoid the rumen contents running out. The carcass is then fixed to the hide pulling equipment and the hide of the forelegs is fixed with hide clamps to the puller. The hide pulling equipment pulls the skin off. The equipment operates down–up, or up–down, the latter being better from a hygienic point of view, as there is a smaller risk of contamination from the skin, especially in the very end of the unit operation when the hide comes off the carcass fiercely. After dehiding, the brisket is opened with a brisket saw; the anus is detached, covered with a plastic bag and then pushed into the coelom. Then, the frontal side is opened with a knife or opening device, with the sharp edge outwards to avoid cutting the intestines. Casings, stomachs and oesophagus are removed, followed by the lungs, heart, liver, spleen, pancreas and tongue. The kidneys, again, stay in the carcass until the veterinary inspection. Spinal cord and brains are treated separately because they are materials at risk of BSE (bovine spongiform encephalopathy caused by prions). The carcass is then inspected, stamped, graded, weighed and, finally, cooled. Sheep and goats are slaughtered in basically the same way.

4-Cooling/chilling

Beef, sheep and goat carcasses are cooled to inhibit the growth of microorganisms and to minimize the water loss during chilling. The normal system for chilling ruminants is a batch process where the carcasses are placed in chill rooms and then cooled together. The air temperature in the chill room is 0–5 °C with air circulation in the range 0.7–1.5 m/s. It usually takes around 18 hours to reach the ultimate muscle pH in sheep and 24–36 hours in beef. A general rule is to avoid a muscle temperature below 10°C for at least 10 hours after slaughter and the pH must reach 5.7 before the temperature falls below 7°C. Shrinkage during cooling is an important economic factor and, for beef carcasses, water loss through evaporation is typical between 1 and 2% during the initial 24 hours of the chilling process. Shrinkage can be reduced by maintaining a low temperature, using a low velocity of circulating air and maintaining a high relative humidity. Spray chilling of beef and lamb carcasses with cold water mist in cycles during the first 3–12 hours has been shown to reduce carcass shrinkage. Lamb is susceptible to cold shortening due to: a high surface-to-volume ratio leading to faster cooling; a relatively high amount of red fibres – more red muscles are generally more prone to cold shortening; a relatively slow glycolysis rate.



Flow diagram: beef slaughter, cutting and packing.

Slaughterhouse sanitation (Aims)

1) To reduce the risk of food poisoning and foreign body contamination.
2) To maintain a general quality ethos within the entire organisation.
3) To meet retail customers' and consumers' quality expectations.
4) To allow maximum plant productivity.
5) To ensure the safety of operatives and maintenance staff.
6) To help secure the shelf life of the products.
7) To avoid pest infestation.
8) To protect marketplace reputation.

Cleaning in general

Physical, chemical and microbiological cleanliness is essential in food processing plants.

1. Physical cleanliness means that there is no visible waste or foreign matter on the process and equipment surfaces.
2. Chemically clean surfaces are surfaces from which undesirable chemical residues have been removed.
3. Microbiologically clean surfaces imply freedom from spoilage microbes and pathogens.
4. Attached bacteria or bacteria in biofilms can be a problem in food processing because these cells can stick firmly to the surfaces. Once biofilms are formed, cleaning and disinfection becomes much more difficult. Especially in cases where the cleaning is insufficient, the remaining bacteria can start to multiply and grow in humid conditions immediately after the cleaning has been performed. Thus, products treated on these surfaces will be contaminated. The elimination of surface-attached microbes or microbes in biofilms is a very difficult and demanding task in which both detachment and the microbicidal effect of the agents on microbes should be taken into account. Mechanical treatments in cleaning are the most efficient ways of eliminating biofilms but frequently the structure of the equipment makes this difficult.

<u>The key to effective cleaning of a food plant</u>:

1. Understanding of the type and nature of the soil (*e.g.* fat, protein, sugar and mineral salts) and of the microbial growth on the surfaces to be removed.
2. An efficient cleaning procedure consists of a sequence of rinses and detergent and disinfectant applications in various combinations of temperature and concentration.

3. The personnel must be properly trained and responsible to maintain a good level of process hygiene in the food plant.

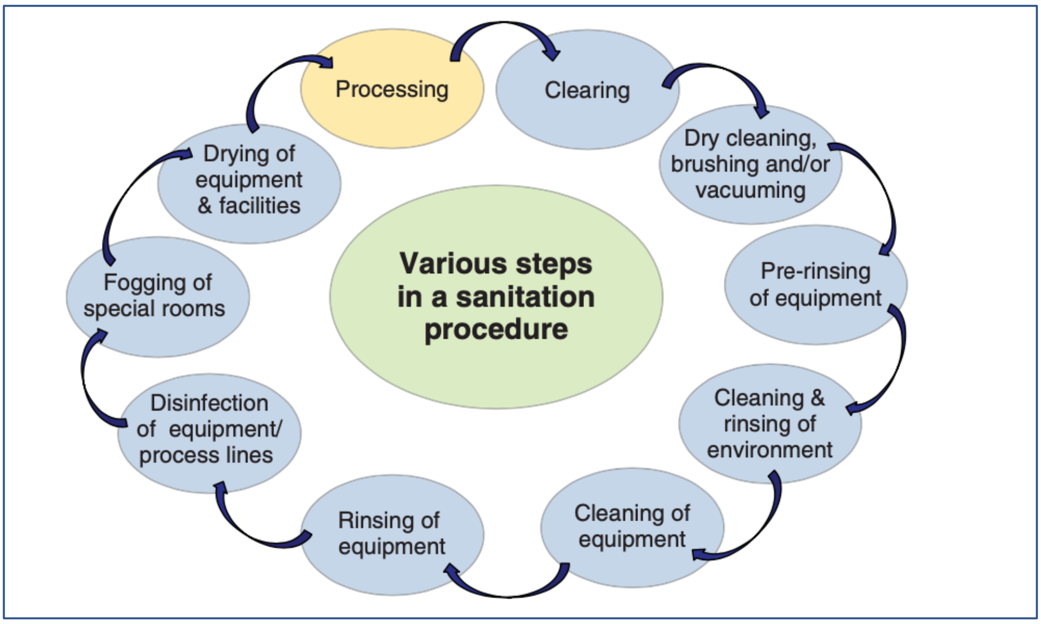


Figure 1. Steps of the sanitation procedure.

Main soil types and their removal

In slaughterhouses fats and proteins are the most common types of soil. Often the soil is a mixture of protein and fat. Smears of protein and fat can also contain detergent residues as well as mineral salts of calcium and magnesium from hard water. This type of smear can be found where the cleaning procedure is irregular or based on incorrect working routines with the use of the wrong detergents. This waxy mass is not soluble in alkaline or acid solutions. The only way to remove this type of smear is by using mechanical force. Often, manual scrubbing with pads or scrubbing with brushes is the only way to remove this type of residue. It is important to differentiate mineral salt deposits, which are soluble in an acidic environment, from waxy mass. Fat can easily be removed using hot water (50–60°C) to give an optically clean surface and the efficiency can be improved by adding a detergent. Removal of protein depends on the treatment that the soiled surface has been exposed to before the cleaning procedure is started. If the surface has been treated with hot water (≥60°C) for a long time the soil is very difficult to remove.

Energies of cleaning

A principle of prime importance is that every cleaning process, of whatever kind, always involves a combination of four factors:

1. *Thermal energy*, in the form of hot water or steam. As a rough guide, an increase in temperature by 10°C in a detergent solution *doubles* the rate of the chemical reactions involved in cleaning.
2. *Mechanical energy*, in the form of brushes, water jets, turbulent flow in pipes or even the micro-agitation produced by the bursting of foam bubbles. In cleaning-in-place (CIP) of pipe systems, a flow rate of about 2 m/s is needed to ensure turbulence and avoid laminar flow, discussed in more detail later.
3. *Chemical energy*, which depends on the nature and concentration of the detergent used.
4. *Time*, which varies from hours in the case of soak cleaning to seconds in the case of tray or crate cleaning in industrial washing machines.

Choosing the disinfectants

The purpose of disinfection is to destroy microbes by chemical or physical means. The disinfectants must be effective, safe and easy to use, and easily rinsed off surfaces, leaving no toxic residues or residues that affect the sensory values of the product. A disinfectant with a broad spectrum is recommended for most purposes. Disinfectants approved for use in the food industry are alcohols, chlorine-based compounds, quaternary ammonium compounds, oxidants (peracetic acid, hydrogen peroxide, ozone), persulfates, surfactants and iodophors.

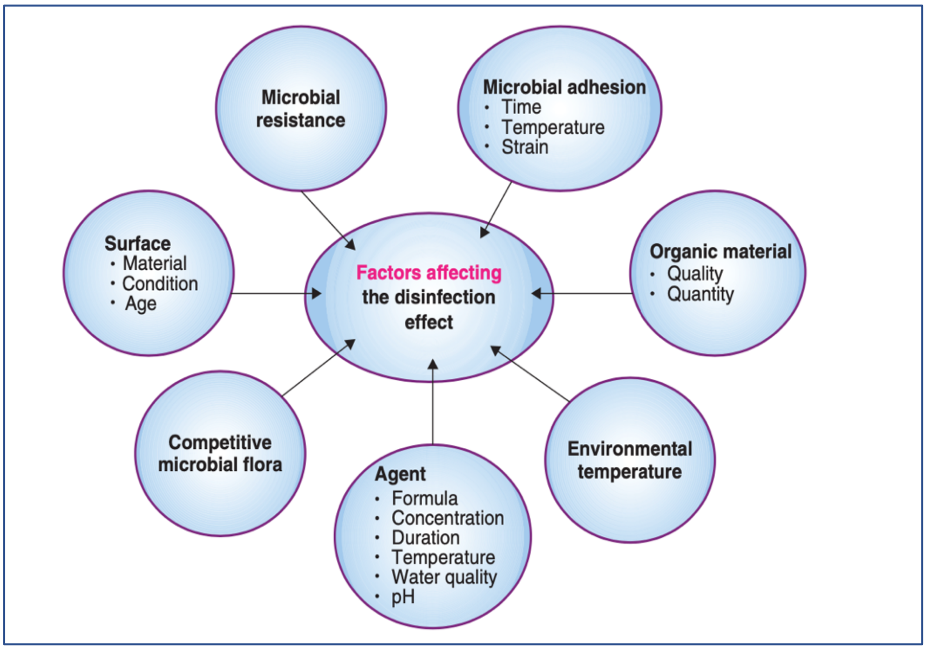


Figure 2. Factors affecting the disinfection

Water temperatures

Although the EU regulations call for 82°C water to be used for knife sterilisation, such high temperatures are impractical for most plant cleaning operations for a number of reasons:

1. The steam, humidity and condensation obscure vision and encourage microbial growth.
2. Proteins are denatured on the surfaces and hard-water scale formation is increased.
3. The load on the extraction and cooling systems is increased.
4. Thermal shock can damage surfaces owing to differential expansion.
5. Pipe work lifetime is reduced.
6. The lances are too hot to hold and the water jet is dangerous.
7. Energy costs are too high.
8. Foam quality deteriorates at very high temperatures

Monitoring of hygiene

Monitoring of cleaning and disinfection effectiveness is partly a matter of trained *visual assessment* and partly of *surface analysis and microbiology*. A plant that is not visually clean always presents a risk regarding the microbial contamination of food. The control and avoidance of food safety risks are, as mentioned earlier, best achieved using a **HACCP approach** (**Hazard analysis and critical control points)**