Disinfection in the dairy parlour

A. SARAN *

Summary: The dairy farmer has the responsibility of producing milk under clean and hygienic conditions, employing appropriate techniques to clean and disinfect the milking equipment and the milking parlour. The ability of raw milk to retain its quality under storage, and the safety of the product for the consumer, can both be directly related to the bacterial content of the milk. In most countries, bacterial content is one of the factors considered in determining the level of payment for milk.

Cleaning and disinfection are complementary processes: neither process alone will achieve the desired end result. Milk with low bacterial and somatic cell counts cannot be produced unless milking equipment is effectively cleaned and disinfected between milkings and the cows are kept healthy.

The author considers the various sources of bacterial contamination and increased somatic cell counts in raw milk, and describes the cleaning and disinfection practices recommended for the production of milk of good microbiological quality.

KEYWORDS: Cleaning procedures - Disinfection - Milk hygiene - Milking machines - Milking parlours - Milk production.

INTRODUCTION

The hygienic quality of milk affects the health of the consumer and the quality of the end product, and is therefore commercially important. The dairy farmer has the responsibility of producing milk under clean and hygienic conditions, employing approved techniques and procedures to clean and disinfect the milking equipment and milking barn.

The safety of raw milk for the consumer and the ability of raw milk to retain its quality during storage directly relate to the bacterial content of the milk. In most countries, bacterial content is one of the factors considered in the milk payment scheme.

When producing raw milk of good bacteriological quality, cleanliness and disinfection of the udder and the milking equipment are the most important requirements, even more so than cooling the milk. Cleaning and disinfection are complementary processes; neither process alone will achieve the desired result, which is to leave the surface of milking utensils as free as possible from milk residues and bacteria (5, 26).

The bacteriological quality of milk is determined by various aspects of dairy management and husbandry practices. Milk is sterile when secreted by an udder gland.

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which is free from infection. Contamination with microorganisms occurs during and after milking. As the average number of dairy cows per herd has increased in recent years, greater numbers of animals have tended to be concentrated in each production facility, thus creating a greater risk of exposure to pathogens for the individual animal, due to increased bacterial contamination of the premises. High levels of moisture in the dairy farm environment allow bacteria to grow and multiply, and increase the possibility of bacteria reaching the teat apex, leading to a greater risk of bacterial penetration into the mammary gland (29, 30).

Commercial dairy operations in most countries have increased in size and complexity. Automation is replacing manual labour in the barn. With automated removal of the milking unit, the operator is no longer required to return to the cow at the end of milking, and therefore post-milking teat disinfection is frequently inadequate or is abandoned altogether. Workers responsible for a large number of cows and milking units have little opportunity for observation of individual cows, and thus mild cases of udder diseases may pass unnoticed and untreated. The availability of automated systems has prompted many dairy producers to introduce thrice-daily milking, and continuous genetic improvements have increased milk yield, thus creating an environment conducive to a higher level of udder infection and a heavier charge of contaminating microorganisms. Hygiene plays a primary role in reducing the burden of the many pathogens present in the dairy farm environment (7).

This article considers the sources of bacterial contamination of raw milk, and the recommended cleaning and sanitation practices necessary for the production of milk of good microbiological quality. Milk quality is determined by the following factors:

- **a)** udder diseases or 'internal' milk contamination
- **b)** contamination of milk from the udder and teat skin
- **c)** contamination of milk from milking equipment and the milking barn
- **d)** multiplication of bacteria in milk during storage in the farm and transport to the processing plant.

### UDDER DISEASES AND MILK CONTAMINATION

Mastitis is the most widespread infectious disease affecting dairy cattle. The chronic, sub-clinical form of mastitis may affect cows throughout their productive life, while the clinical form usually attacks high-producing cows in the first months after parturition. Both forms of the disease cause deleterious changes in milk quality and composition. Infected glands cause fluctuating numbers of microorganisms to be excreted in milk, the highest numbers being found in foremilk (2, 15).

Bovine mastitis is a multifactorial disease complex resulting from the interaction of the cow, the environment and the microorganisms pathogenic for the udder. Major losses from mastitis include those due to decreases in milk production, the cost of replacement heifers, loss of unsaleable milk following the administration of antibiotics, the cost of drugs, veterinary treatment, extra labour, and the loss of genetic material from the herd.

Sub-clinical mastitis is caused by udder pathogens which multiply in the mammary gland and are essentially contagious, being spread between cows principally at milking
time in the parlour, due to contact with the hands of the milker, udder cloths and the rubber liner of the milking unit. The main pathogenic organisms involved are staphylococci, *Streptococcus agalactiae* and *Streptococcus dysgalactiae* (11).

The bacteria causing clinical mastitis multiply principally in faeces and bedding, and in the water supply. Thus, udder contamination principally occurs via the environment outside the parlour, the main ‘environmental’ organisms being *Escherichia coli* and coliform enteric bacteria, *Streptococcus uberis* and *Actinomyces pyogenes*.

Control of sub-clinical contagious mastitis must concentrate on the cows, the milking parlour or the barn, and may be achieved by teat disinfection (post-milking teat dipping) and treatment, preferably during the ‘dry’ period. On the other hand, control of environmental clinical mastitis-causing pathogens must concentrate on general cleanliness and dryness, ventilation, effective disposal of discharges, fly control and adequate sanitation of the milking machines. The hygienic preparation of the udder before milking is essential for the control of both forms of mastitis, although such treatment is more effective in the prevention of the clinical form (27, 28). The infecting bacteria lead to mammary gland response, including stimulation of the migration into the udder of leukocytes or white blood cells which ingest and kill invading bacteria, releasing compounds that cause inflammation, tissue damage and alteration of the secretory functions of the gland. Mastitis alters milk composition: lactose and fat levels fall, and there are major changes in milk proteins (decrease in casein). Sodium and chloride ion concentrations in the milk rise and the level of potassium falls. This causes increased electrical conductivity, a factor which is used for detection of mastitis; other methods include counting the somatic cells (both leukocytes and desquamative epithelial cells) in milk. This last marker for the detection of mastitis (mainly sub-clinical), together with the total bacterial count, is currently employed in many countries for calculations in milk quality payment systems (Table I). Clearance of udder infection in dairy cows by treatment, segregation and culling will not be considered here. This discussion will concentrate on the techniques of prevention and hygienic milking recommended for diminishing the rate of new infection with contagious sub-clinical mastitis and thus improving the bacteriological quality of raw milk (6, 13).

**Hygienic procedures in controlling mastitis**

For practical reasons, milking parlour sanitation can be separated into three main phases: pre-milking sanitation, cleansing of the milking unit after each cow, and teat disinfection after milking.

Teat disinfection after milking will be dealt with in the next section, while the other two phases will be covered in the sections ‘Contamination of milk from the udder and teat skin’ and ‘Contamination of milk from milking equipment’.

**Teat disinfection after milking**

The value of post-milking teat disinfection is now widely accepted (Table II) (16, 22). Farmers who consider this procedure too laborious and expensive should be reminded that it takes an average of 4-6 seconds per cow to apply, uses approximately 7.5 l of disinfectant per cow per year for twice-daily milking (11.25 l/day for thrice-daily milking) and costs approximately US$23 and US$35 annually for twice- and thrice-daily milking, respectively.
### Table I

*Milk payment according to somatic cell counts in member countries of the International Dairy Federation* (3)

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Teat disinfection aids in reducing contagious mastitis infections caused by staphylococci, *Streptococcus agalactiae* and the *Mycoplasma* species. There is good evidence that, when practised continuously, teat disinfection after milking reduces new udder infections due to these organisms by 50% or more, although this practice appears to offer very little protection against environmental pathogens, such as coliforms.
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A: advice on management and housing  
B: milking machine testing and maintenance  
C: teat washing before milking  
D: teat disinfection before milking  
E: teat disinfection after milking  
F: dry cow therapy  
G: treatment of clinical cases  
H: culling chronic cases  
I: cell counting  
J: routine bacteriological examination of cows  
K: other measures  
1: guidelines for machine milking  
2: California mastitis test (a cow-side mild somatic cell estimation) every two weeks  
3: feeding advice  
4: not stated  
5: milking management  
6: checking milk residues; bacterial counts  
ND: no data
**Techniques**

The most widely-used methods of teat disinfection are described below.

**Manual teat dipping**

Manual teat dipping provides good coverage of the teat skin and is the most popular method of teat disinfection. The disinfectant solutions are applied from an open cup or a closed, non-spill cup (which reduces wastage and requires less refilling during milking). When sufficient clean disinfectant solution is maintained within the dip cup, the teats of approximately 25 cows may be dipped after milking without refilling the cup with fresh solution. The solution remaining in the cups should be disposed of after the completion of milking, and the cups should be washed clean and maintained dry until the next milking. Some milkers object to using disinfectants, and occasionally suffer allergic reactions from disinfectants splashing onto their hands.

**Manual teat spraying**

Manual teat spraying involves the use of a pressurised container fitted with a suitable nozzle, best positioned at the curved end of an elongated spraying tube. Milkers who prefer spraying claim that less disinfectant is used and that the solution is always cleaner and of more uniform concentration than that used for dipping. However, when spraying is performed quickly, teats may be missed; in udders with abnormally-positioned teats, a teat may be shielded by a leg. The risk to operators of continuously inhaling the chemical droplets has motivated the wider use of the dipping technique.

**Automatic teat disinfection**

Devices for automatic teat disinfection after milking are usually cow-activated and are positioned at the exit from the parlour. Most devices are experimental and only a few are sold commercially. When built and operated correctly, these devices can achieve good coverage of the teat ends and teat sides. As there is no need for workers to be close at hand during operation, no inhalation of chemical droplets occurs. A disadvantage of automatic devices is that they use twice as much disinfectant as manual spraying.

**Teat disinfectants**

Among the disinfectant products most widely used for teat disinfection are iodophors, chlorine-releasing compounds and chlorhexidine. Most commercial preparations add emollients or dermatological excipients, such as glycerine or lanolin, to improve teat skin tolerance under continuous use.

**Iodophors**

Iodophors are the most widely-used teat disinfectants in most countries (23). These include certain surface-active agents (usually a non-ionic surfactant) which solubilise iodine and form compounds possessing the germicidal activity of iodine without the toxic and irritant properties. Iodophors are microbicidal. When iodophors are diluted with water, the iodine micelles aggregates are dispersed and most of the iodine is slowly liberated. The microbicidal activity encompasses bacteria, bacterial spores, fungi and their spores and some viruses. Iodophors remain potent in the presence of organic matter, provided that the pH does not rise above 4. The activity of iodophors decreases markedly when diluted in water with a high level of alkaline hardness. Iodophors are formulated with phosphoric acid to provide a pH of approximately 3 for optimal antimicrobial activity. Povidone-iodine (a water soluble complex of iodine and polyvinylpyrrolidone) is a general antiseptic used in some countries for teat disinfection.
The recommended concentration (free iodine) of commercial iodophors for teat disinfection in most countries is 0.5% (5,000 ppm). In some regions, higher concentrations (1.0%) are used, but a tendency towards using lower disinfectant concentrations during milking has recently been observed in some countries. This policy is aimed at reducing the risk of milk contamination with chemical residues, thus ensuring a higher-quality and more wholesome product for consumers. Published evidence is available on the efficacy of iodophors for teat disinfection at concentrations of 0.25% or lower (23). With these lower concentrations, more frequent refilling of the dip cup is required: each refill may be used for up to 15 cows instead of 25. The staining properties of iodine are present, although diminished, in iodophor preparations; such staining is useful as it shows whether the cows have been correctly treated.

**Chlorine-releasing compounds**

The most commonly-used chlorine-releasing compound is sodium hypochlorite, which has a wide antibacterial spectrum, although it is not effective against mycobacteria. The activity of sodium hypochlorite is markedly affected by organic matter and light. Chloramine compounds have also been used as teat disinfectants. Both types of disinfectants are more stable in alkaline solutions at concentrations varying from 0.1% to 4% (1,000-40,000 ppm) without emollients, and with a pH between 8.5 and 11. These compounds are active against staphylococci and *Streptococcus agalactiae* and are usually cheaper than other disinfectants. The limited use of chlorine-releasing compounds compared with the other groups is explained by their pungent odour, and their capacity to induce decolouration of fabrics and some irritation of teat skin. Isocyanuric is a less irritating chlorine-releasing compound used in some countries, which is usually supplied in the form of effervescent tablets and is recommended for use at concentrations of 0.5% (5,000 ppm).

**Chlorhexidine**

Chlorhexidine is a member of the biguanide group of disinfectants; it has bactericidal properties against Gram-positive and Gram-negative bacteria and is antifungal, being more active at alkaline pH. As this product is colourless, some commercial preparations include the addition of approved artificial colourants, which leave a mark on the teat skin similar to that left by iodophors.

Chlorhexidine has a longer residual activity on teat skin than other groups of disinfectants. This property is important, due to the increased contact time for antibacterial activity on the resident skin bacterial population and the preventive activity against skin contamination with environmental organisms during the period after milking (when the teat canal is not yet closed and the danger of bacterial penetration into the gland is increased). Organic matter does not greatly affect the activity of chlorhexidine. Recommended concentrations for teat disinfection are usually higher than with iodophors, i.e. approximately 0.5% (5,000 ppm). As the solubility of chlorhexidine depends on water quality, the daily preparation of solutions is recommended in regions with alkaline hardness in the water supply.

Other disinfectants with limited use for post-milking teat disinfection are quaternary ammonium compounds (used in Canada, France and the United Kingdom), glutaraldehyde (Switzerland, France and the United Kingdom), linear dodecylbenzene-sulfonic acid (LDBSA) (Canada, the United States of America [USA], Denmark, Finland, Spain, France, Belgium and the United Kingdom), chlorous acid and chlorine dioxide (Canada, the USA and France).
Disinfectants should be formally approved and registered. In most countries, registrations are performed by the Ministry of Agriculture, and approval and registration must be clearly marked on the product packaging, together with complete instructions on dilution and application, and warnings of potential risks to animal and human health and of possible residues in milk.

In view of the need to protect the teat duct orifice, which is usually open to some degree for a short period after milking, disinfection of teats immediately after milking should be recommended.

**CONTAMINATION OF MILK FROM THE UDDER AND TEAT SKIN**

Sanitising the udders of cows prior to milking reduces the opportunity for environmental organisms to gain entrance into the raw milk and reduces exposure of the udder to these organisms.

The many types of microorganisms which colonise the external surfaces of the udder and teats include faecal, soil and water coliforms (*E. coli, Enterobacter aerogenes, Klebsiella* spp.), streptococci (mainly *S. uberis*), staphylococci, coryneform organisms, bacilli, yeasts and fungi (18). Continuous post-milking teat disinfection greatly reduces the population of organisms on the teat skin. However, such procedures have almost no effect on bacterial populations obtained by cows lying down in an infected environment, or contamination due to contact with the hands of milkers, washing water or cloths. Wet skin is known to shed more bacterial colonies into milk than dry skin. It has been demonstrated that different methods of pre-milking udder preparation significantly influence milk quality. The lowest bacterial counts in milk were observed when teats were cleaned with water followed by thorough drying with individual paper towels, or when a disinfectant was applied to teats followed by drying (12). Pre-milking teat disinfection by teat dipping in association with good udder preparation reduced the rate of intramammary infections due to environmental pathogens by 50% (compared with good udder preparation alone) (24). A common practice is to wash but not dry the teats; this has a deleterious effect on the bacteriological quality of milk, increasing the risk of coliform and *S. uberis* mastitis, as these bacteria are often present on the teats before milking and might run down with the water onto the teat apex in the course of milking.

A basic approach to recommended preparation of cows for milking in the milking parlour should include the following elements:

a) Identify cows (udder quarters) secreting abnormal milk and discard this milk; it is not fit for human consumption and should not be mixed with the milk of healthy cows for further processing. In most countries, this point is enforced by official regulations. Foremilk examination is the technique used to identify abnormal milk before applying the milking unit. Although milk filtration removes larger particles of dirt and sediment, it cannot remove bacteria, and thus a filter does not provide an alternative to good management and husbandry practices, if good raw milk quality is the required goal.

b) Clean and disinfect the teat skin, thus reducing the bacteriological contamination of raw milk. The efficacy of teat washing is increased if an approved disinfectant is added to the wash water. Additionally, washing teats one minute before milking provides a stimulus for the milk ejection reflex.
Inevitably, handling and washing the teats of cows in the milking parlour transfers pathogenic organisms between teats and between cows. To minimise this transfer, it is necessary that a disinfectant is included in the washing solution, that an individual clean cloth or paper towel is used for each cow, and that the hands of the milker are washed and dried before preparing each cow for milking. Wearing rubber gloves is advisable but this practice is not widely accepted by milkers, particularly in hot climates.

The disinfectant employed is usually either chlorine (in a concentration ranging from 100 to 300 ppm) or an iodophor (in a concentration between 25 and 75 ppm). Cloths or towelettes impregnated with disinfectant were found to be effective for pre-milking teat preparation (1), and should be recommended for individual cow use (one towelette per cow).

c) A complement of pre-milking udder and teat preparation, developed in the USA and indicated mainly to reduce the incidence of environmental mastitis, is pre-milking teat disinfection by dipping or spraying with chlorine-based disinfectants or iodophors (12, 17, 24, 25), usually at lower concentrations than for post-milking disinfection. Chlorine compounds are used for pre-milking teat disinfection at 20,000 ppm (in the United Kingdom) and iodophors are used at between 1,000 and 2,500 ppm. In some countries (Spain, the USA and Canada), chlorhexidine is used at 1,100-5,000 ppm. LDBSA is used at concentrations of 19,400 ppm (in the USA and Denmark), and chlorine dioxide and hypochloric acid at 30,000 ppm (also in the USA and Denmark). Nisin, a proteinaceous antimicrobial bacteriocin, is used in France. In pre-milking teat disinfection, the formulation must be applied to the whole teat surface, which has been previously cleaned. After a minimum of 10 seconds, the teats must be wiped dry with a paper towel to remove excess disinfectant. It should be stressed that pre-milking dipping or spraying is not a substitute for cleaning and washing teats in the usual way; these procedures are simply additions to a good pre-milking hygiene routine and do not represent alternative methods of udder preparation.

The numbers of bacteria shed in the milk from an infected udder may exceed $10^9$/ml, particularly in cases of clinical mastitis. Even a single case of mastitis can significantly increase the bulk milk bacterial count in a medium-sized herd. Dirty teats are the main source of visible extraneous matter or sediment content, and may lead to bacterial counts approaching 100,000/ml in milk. Heavily-soiled, unwashed teats may produce an unacceptable sediment in milk. However, when cows are on pasture in dry weather, the bacterial count of milk from unwashed teats may be less than 100/ml.

**CONTAMINATION OF MILK FROM MILKING EQUIPMENT**

Surfaces of milking and cooling equipment which come into contact with milk are the main source of milk contamination, and are frequently the principal cause of consistently high bacterial counts. Relatively simple and inexpensive cleaning and disinfection procedures can effectively diminish bacterial contamination from this source in milk. However, faults arise which may result in a build-up of potentially pathogenic bacteria, mainly pseudomonads, coliforms and enterococci, on the milking equipment surfaces. Common among such faults are inadequate water temperatures, over-dilution of detergent sanitisers, failure to ensure adequate contact time with the soiled surfaces, and rubber inflations (liners of the milking unit) and tubes in poor condition. Although rubber inflations are not contaminated for the first cow being
milked with the unit, they potentially transfer pathogenic and saprophytic bacteria originating from within the udder, from the udder and teat skin, and from faeces to cows subsequently milked with the same unit (10, 14).

It is virtually impossible to remove all milk deposits and residues from the milk-contact surfaces of milking equipment. Bacteria multiply on these surfaces in the interval between milkings, especially in regions with a hot or moderate climate. High numbers can be present on apparently clean equipment. It is essential to recommend the use of milking equipment with smooth milk-contact surfaces, with a minimal number of joints, dead ends and crevices, the use of a water supply of drinking quality, detergents to remove milk residues and sediment, and disinfectants to eliminate bacteria (4, 8). Due to the complexity of milking machines, cleaning and disinfection of milk-contact surfaces may not be fully effective, so that milk residues and bacteria are not completely removed from the equipment and thus accumulate daily. The extent of bacterial contamination on milk-contact surfaces of equipment is usually determined by rinsing with a sterilised liquid. This liquid is then subjected to a bacterial count in the same way that milk is tested, and any bacterial species present can be determined.

Methods of cleaning and disinfecting the milking equipment will be described below, with reference to the various milking systems generally employed. Selection, storage and handling of disinfectants and detergents are also discussed.

**Manual cleaning**

Washing by hand is appropriate for bucket milking machines and clusters, and for ancillary equipment (e.g. receiving pans, strainers and coolers) used when milk is put into churns. Manual cleaning may also be used for smaller bulk tanks. The daily cleaning routine consists of three stages: a rinse with cold or tepid water (38°C), a warm detergent wash and a final rinse with clean water (31).

The cold or tepid water rinses remove residues of milk which would otherwise partially inactivate the disinfectant in the next stage. Tepid water is particularly beneficial for rinsing the clusters, as this is more effective than cold water in removing fat and milk residues. After milking, the outside of the milking unit is cleaned. Each unit should be rinsed by connecting the vacuum tube to a vacuum tap and drawing clean water through the teat cups. If the clusters are not cleaned immediately, they should be left immersed in water. The next stage, the warm detergent-disinfectant wash, is the most important of the three. Unless the solution reaches all milk-contact surfaces, milk residues may remain which will protect bacteria from the disinfectant. Care must be taken to avoid air-locks in the clusters. A volume of 45 l of detergent-disinfectant solution is sufficient for up to three milking units and ancillary equipment. Clusters should be washed first by full immersion for two minutes; teat cups, milk tubes and claws are scrubbed, and the cluster is re-assembled and transferred to the rinsing trough. For the final clean water rinse, the addition of 50 ppm of hypochlorite significantly improves results. The clusters should be rinsed and hung up to drain.

In case of deposits on the milk-contact surfaces or high bacteriological counts, extra steps are required, as detailed below.

**De-scaling with acid**

Phosphoric acid is used to remove milk stone (milk and hard water residues). After cleaning, the metal components of the milking unit are dismounted and soaked in the de-scaling solution, in accordance with the instructions of the manufacturer. All parts
should be brushed with detergent-disinfectant solution and finally rinsed. Eye protection and rubber gloves should be worn when handling the acid.

**Heat treatment**

Should detergent-disinfectant solution be unavailable, heat treatment is necessary. Approximately 9 l of hot water (85°C) should be rinsed through the clusters. A domestic boiler is a convenient source of hot water. After treatment, the equipment is hung up to dry.

**Wet storage of clusters**

Clusters are suspended in a rack in such a way that they can be filled with a suitable detergent-disinfectant solution between milkings.

In the case of milk rejection due to high bacterial counts, immediate attention should be given to the following points:

- Old and worn rubber parts should be replaced, together with metal or plastic equipment which is rusty, corroded or has open seams.
- Metal components should be de-scaled and rubberware soaked in hot detergent-disinfectant solution.
- Daily cleaning and disinfectant methods should be checked and any faults corrected.

**In-place cleaning**

The predominant method of in-place cleaning for milking pipelines and recorder machines is circulation or re-circulation cleaning in barns and parlours. Less common methods, such as the use of acidified boiling water, will also be mentioned below.

**Circulation cleaning**

Circulation cleaning is a three-stage process consisting of a pre-rinse with water, a re-circulated hot wash with detergent-disinfectant solutions and a final cold water rinse. For cleaning particular installations, most manufacturers issue instructions in conjunction with a diagram of the milking installation. The efficiency of circulation cleaning depends on the temperature of the water used for the detergent-disinfectant wash, the optimum initial temperature being at least 85°C. Parlours with large-bore pipeline systems have air-injectors to develop turbulence of the cleaning solution and thus improve surface contact and disinfection efficiency. In parlours with recorder jars, spreader plates and valves are fitted at the top of the jar to improve contact with the internal surfaces, thus ensuring sufficient solution flow through the clusters (20).

Procedures for circulation cleaning are usually indicated by the milking machine manufacturer. Although some differences exist between the various types of milking installations, the generally-accepted procedures are as follows:

1. After milking, rinse the machine thoroughly with warm water, and brush the clusters to remove external dirt.
2. Attach the jetters to the cluster.
3. Check the water temperature (85°C).
4. Drain the milk from the receiver and milk pump.
5. Remove the filter sock (interior) and clean the filter as recommended by the manufacturer.
6. Connect the air pipeline directly to the water heater and set the three-way valve to the washing position so that the hot rinse water is drawn into the machine.

7. Set the releaser milk pump to run continuously and adjust the spreader on the receiver lid to the washing position.

8. Allow hot water to pass through the machine and discharge to waste until the temperature of the water leaving the machine exceeds 50°C.

9. Add approved detergent-disinfectant solution to the measured volume of hot water, in accordance with the specifications of the manufacturer. Set the three-way valve to draw solution from the wash through the installation and continue circulation for 5-10 min. No advantage is gained by prolonging circulation, as the temperature of the solution progressively falls.

10. Discharge the detergent-disinfectant solution by deflecting the delivery pipeline.

11. Run clean cold water into the machine. Sodium hypochlorite may be added at a concentration of 50 ppm to avoid risk of contamination from supply lines.

12. Switch off the releaser and vacuum pumps; drain and prepare the machine for milking.

If a hypochlorite rinse is given for two minutes immediately before milking, it is not necessary to add hypochlorite to the final rinse (step 11).

Some manufacturers provide equipment which automatically controls the circulation cleaning cycle and the dosing of detergent-disinfectant products. Regular and frequent inspection of the installation (performed after the cleaning process) is necessary to detect and correct defects, such as malfunctions in inflations, punctured short milk tubes, leaking rubber joints, flattening of any rubber tubes (which could result in incomplete circulation) and build-up of milk residues.

**Acidified boiling water cleaning**

This method relies on heat for bacterial sanitation. For each cluster, 18 l of boiling water is required, which enters the machine at a predetermined rate and is then discharged. In the first 2-3 min of cleaning, acid (nitric, sulphuric or citric) is added to the water to prevent hard-water salt deposits on internal surfaces. All components should reach 77°C and be kept at this temperature throughout the cleaning process, for approximately 5 min. All components of the milking installation should be checked to ensure ability to withstand the high temperatures and acidity. Extreme care should be taken when handling concentrated acids. Eye protection and rubber gloves should be worn when preparing diluted solutions. A recommended routine for acidified boiling water cleaning at the end of each milking (or alternatively once a day or once a week) is as follows:

1. Brush clean the outside of the clusters and jetters with a detergent-disinfectant solution and fit the teat cups into the jetters.
2. Check that the water temperature in the boiler is at least 96°C.
3. Remove the milk delivery pipe from the bulk tank.
4. Add the stock acid solution to the acid container.
5. Turn the three-way valve to the wash position and open the wheel valve controlling the flow from the water boiler.
6. Adjust the spreader on the receiver lid to the washing position.
7. Set the releaser milk pump to run continuously, to discharge return water to waste.

8. When water flow ceases, stop the vacuum and releaser pumps and drain the machine.

The total flow time should be 5-6 min. All parts of the plant should reach 77°C after 2-3 min.

MULTIPLICATION OF BACTERIA IN MILK DURING STORAGE ON THE FARM

After the bulk milk tank has been emptied, the tank should be rinsed with cold water of drinking quality to remove residues and then cleaned with detergent-disinfectants, using cold or warm water (37°C). If cold water is used for cleaning, addition of iodophor solutions has proved to be effective and has the advantage of rendering film build-up visible.

Cleaning of the bulk milk tank can be performed manually or by mechanical methods.

Manual cleaning of the bulk milk tank

The general routine for manual cleaning is as follows:

1. Brush the dipstick and bulk tank plug with a detergent-disinfectant solution and seal the tank with the blanking plug.

2. Brush and scrub the inner surface of the tank with a detergent-disinfection solution.

3. Drain the solution to waste and replace the dipstick and plug before hosing with clean cold water.

4. Drain the tank and replace the plug. The tank is then ready to receive milk.

Variations to the manual procedure include brushing with special detergent-disinfectant powders which are applied to the wet inner surface of the tank. The powder is worked into a paste by brushing, and spread to cover all the surfaces; after a contact time of two minutes, the tank is rinsed by hosing with cold water. Alternatively, a hand-operated spraying device which introduces iodophor into the stream of water from a cold water hose can be used, with a contact time of 10 min, before rinsing with cold water and draining the tank.

Mechanical cleaning of the bulk milk tank

The same steps described for manual cleaning apply to the mechanical cleaning of the bulk tank, which is performed after milk collection. This may be a totally automatic process or it may be restricted to the first water rinse and cleaning with the detergent-disinfectant solution, leaving the farmer responsible for the final rinse.

The disinfectant is applied by means of a spraying device in the tank. Build-up of milk residues around the joint between the rubber plug and the metal shaft can be prevented by immersing these parts in boiling water for two minutes once a month. Frequent inspection of the interior of the tank and its fittings is necessary. The operation
of the mechanical equipment should also be checked to ensure that the iodophor solution is evenly spread.

Monitoring and assessment of cleaning and disinfection includes inspection of the equipment and examination of the methods used. Bacteriological rinses and swabs from milking equipment are used to test the quality of the final product: raw milk.

**Cleaning and disinfectant agents**

The detergents and disinfectants used in the milking parlour or barn are usually registered or officially approved in different countries by regulatory institutions (usually the Ministry of Agriculture and Ministry of Health). Among member countries of the International Dairy Federation, official registration is required in Belgium, Canada, Denmark, Israel, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom.

A clean water supply of drinking quality is required in the dairy to rinse equipment, prepare cleaning and disinfectant solutions, provide hot or near boiling water, and wash udders and teats.

Legally, all milking equipment must be cleaned and sanitised after each milking, and detergents, detergent-disinfectants and disinfectants are available for this purpose. Cleaning is the most important part of the process, as stressed in the 'Introduction', and if milking equipment is not kept visually clean, chemical disinfectants are unlikely to be effective.

**Detergents**

The addition of suitable detergents to the water used for daily cleaning assists in the removal of milk residues by wetting the surface to be cleaned, displacing the milk soilage, emulsifying fat, dissolving protein, holding soilage in suspension, softening water and preventing sediments during rinsing. No single detergent has all the necessary properties, and therefore commercial detergents usually contain a blend of ingredients. The choice and proportion of the different ingredients are influenced by cost, adverse effects on the hands of operators or on equipment, and the method of application (manual or in-place cleaning systems) (21).

Common ingredients in the detergent formulations are as follows:

- Inorganic alkalis, such as sodium carbonate (washing soda), sodium hydroxide (caustic soda), tri-sodium phosphate and sodium silicates.
- Surface-active agents, such as anionic and non-ionic wetting agents, which increase contact with surfaces.
- Sequestering agents (water softeners), such as polyphosphates and ethylenediaminetetraacetic acid, which chelate hard waters cations.
- Acids, such as phosphoric, nitric and sulphamic acids, which prevent the build-up of milk stone.

Detergents for washing by hand consist of milk alkalis with small proportions of wetting agents and water softeners. For mechanical cleaning, stronger alkalis are considered necessary (to compensate for lack of brushing), together with water softeners. Most commercial detergents are compatible with sodium hypochlorite at normal use concentrations. In dairies with a very hard water supply, extra
polyphosphate is recommended. Acids, sometimes containing wetting agents, are used occasionally to prevent or remove milk stone (19).

**Disinfectants**

Disinfectants may be used alone, or in combination with detergents in ‘detergent-disinfectant’ formulations. The name ‘detergent-disinfectant’ – although universally accepted – may cause confusion as, in fact, a minimal amount of disinfectant is added and the actual disinfection efficiency of such formulations is low.

The main types of disinfectants used in dairies are listed below.

*Sodium hypochlorite*

Sodium hypochlorite is the most widely used disinfectant for milking installations, due to its efficacy as a bactericidal agent; it is also the cheapest disinfectant suitable for use in the dairy. Commercial formulations are supplied in concentrations of between 7% and 12% w/v of available chlorine, with up to 2% free sodium hydroxide. Sodium hypochlorite may be combined with a detergent to allow cleaning and disinfection to be performed in a single operation.

*Chlorine-releasing compounds*

The chlorine-releasing compounds commonly used in dairies include salts of di- and tri-chloroisocyanuric acid and dichlorodimethyl hydantoin.

*Quaternary ammonium compounds*

The foaming properties of quaternary ammonium compounds make these products suitable for manual cleaning and for use in processing plants, but not for circulation cleaning in combination with detergents.

*Iodophors*

Iodophors are complexes of iodine with surfactants, combining high iodine availability with low irritancy and odour, and formulated with acids to enhance the bactericidal properties. Iodophors are widely used for spray cleaning and disinfection of bulk tanks. Low-foam formulations are available for circulation cleaning.

**STORAGE AND HANDLING OF CHEMICALS IN THE DAIRY**

All chemicals should be kept out of the reach of children and all unauthorised persons. Registered chemical agents should be used before the expiry date indicated on the label. All concentrated chemicals should be handled with care and in accordance with the warnings on the label. Eye and hand protection is strongly recommended when handling caustic soda and concentrated acids.

Detergent-disinfectants lose strength when exposed to light and heat, and they should therefore be stored in a cool, dark and dry place. Different chemicals should not be mixed, as this may cause a dangerous reaction. The detergents and disinfectants used in milking parlours should not have a strong smell. The following should be clearly marked on the containers of an approved disinfectant:

- a notice that they contain an approved disinfectant
Le lait fourni par les fermes laitières doit être produit dans des conditions de propreté et d'hygiène, en faisant appel aux techniques appropriées pour nettoyer et désinfecter le matériel et la salle de traite. La capacité du lait à conserver sa qualité lorsqu'il est entreposé et son innocuité pour le consommateur sont fonction directe de sa teneur en bactéries. Dans la plupart des pays cette teneur est l'un des facteurs pris en compte pour déterminer le prix d'achat du lait.

Le nettoyage et la désinfection sont des traitements complémentaires : ni l'un ni l'autre ne permet à lui seul d'atteindre le résultat recherché. On ne peut produire du lait à faible taux de bactéries et de somatocytes sans procéder au nettoyage et à la désinfection du matériel de traite entre chaque mulsion et sans s'assurer que les vaches sont en bonne santé.

L'auteur étudie les diverses causes de contamination bactérienne et d'augmentation du nombre de somatocytes du lait cru. Il décrit les pratiques de nettoyage et de désinfection recommandées pour produire du lait de bonne qualité microbiologique.

MOTS-CLÉS : Désinfection - Hygiène du lait - Machines à traire - Méthodes de nettoyage - Production laitière - Salles de traite.

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**DÉSINFECCIÓN EN LAS SALAS DE ORDEÑO. – A. Saran.**

**Resumen:** El productor de leche debe cumplir determinadas condiciones de limpieza e higiene, siguiendo técnicas apropiadas para limpiar y desinfectar los ustensilios y la sala de ordeño. La capacidad de la leche cruda para conservar su calidad una vez depósito y su inocuidad para el consumidor dependen directamente de su contenido bacteriano. En la mayoría de los países éste es un factor que se tiene en cuenta para determinar el precio de la leche.

Limpieza y desinfección deben considerarse operaciones complementarias: una sin la otra, por sí sola no permite alcanzar el objetivo deseado. No es posible producir leche con porcentaje bajo de bacterias y de somatocitos sin limpiar y desinfectar el material de ordeño cada vez que se ordeña y sin cerciorarse de que las vacas gocen de buena salud.
El autor estudia las diversas causas de contaminación bacteriana y de aumento de cantidad de somatocitos en la leche cruda y describe las prácticas de limpieza y desinfección recomendables para una producción lechera de buena calidad microbiológica.

PALABRAS CLAVE: Desinfección – Higiene de la leche – Máquinas de ordeñar – Métodos de limpieza – Producción lechera – Salas de ordeño.

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