Use of disinfectants in open-air dairying

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Summary: Disinfection systems are essential in providing dairy foods which are safe for consumption by all sectors and age groups of the human population.

The New Zealand dairy industry ensures quality competition under International Organisation for Standardisation (ISO) general systems standards (ISO 9002 and ISO Guide 25) and is subject to food safety assurance legislation (Dairy Industry Regulations 1990). This latter regulation requires that safe foods be produced in accordance with Product Safety Programmes approved by the Ministry of Agriculture and Fisheries. Safety can be demonstrated by compliance with the Codes of Practice of the industry. Farm dairy detergents and sanitisers must be approved for use. These disinfection systems are described.


INTRODUCTION

Dairy production is affected by seasonal variation in the following factors: climate, pasture, synchronous lactation, sanitation challenge, corrective action and therapy.

Product quality can be expressed as the sum of a number of related factors, namely safe pasture, healthy cows, hygienic practices, statistical checks, penalties and prohibitions.

Defects in dairy products are prevented through the operation of quality control systems, approval of incoming goods, veterinary and other services, programmes and codes.

PRACTICES, CODES AND STANDARDS FOR DETERGENTS AND SANITISERS

The code of practice currently in force in New Zealand with regard to manufacturers of detergents and sanitisers specifies the use of quality system certification and food safety approval under International Organisation for Standardisation (ISO) standards ISO 9001 and ISO 9002 (5).

The New Zealand Ministry of Agriculture and Fisheries (MAF) has published a handbook of standards and analytical methods for sanitisers (29) which contains the following specifications:

- Detergents and sanitisers, when used in accordance with the label and other instructions, should perform without compromising food safety, and should protect this by contributing to effective sanitation.
- Approval information is to be evidential with levels of independence for toxicity and efficacy.
- Raw materials are to be safe with regard to toxicity and purity.
- For raw material sanitisers, information on the formulation should be supplemented by antibacterial information.
- Formulations must be manufactured safely and consistently, in accordance with ISO 9002 (certification laboratories will need to meet the requirements of ISO Guide 25 [26]).
- Quality control is required for formulations of actives and for impurities.
- The label/instructions must provide for quality assurance of use (including sanitiser concentration, temperature, time, foam level, pH, and any water hardness limitation).
- There should be no apparent adverse side-effects due to taint, corrosion, inhibition, insolubility or inhomogeneity.
- The ability of detergents to clean and sanitisers to sanitise should be in line with food safety standards and industry safety margins. Cleaning and sanitation should be measured using the following criteria:
  - dairy output (milk) microbiological performance
  - plant visual and/or microbiological performance
  - equivalence to major approved products or standards in field (reference) tests or laboratory tests.

(It should be noted that MAF also offers checks for safe effluent discharge with regard to aquatic toxicity/degradation, and that phosphate is of relatively little importance in New Zealand due to the small catchment areas in this country. Only domestic detergents have formal environmental clearances, which are given in accordance with the Environmental Choice Programme of the Testing Laboratory Registration Council.)

**OVERCOMING DIFFICULTIES IN TESTING THE PRACTICAL EFFICACY OF SANITISERS**

The following are among the difficulties of testing the practical efficacy of sanitisers:
- separate measurement of cleaning, kill and safety is difficult under use conditions;
- laboratory conditions vary from use conditions (which also vary with season and between dairies);
- the effect of conditions on sanitising agents may vary;
- milk quality cannot be easily defined in terms of microbiology (e.g. indicator tests for sanitisers, and 'classical' and 'rapid' routine quality control tests) (27);
- there is a varying contribution to microbial counts from the following factors:
  - varying equipment effects (unswept surfaces are most important)
  - bovine streptococcal mastitis (can cause high aerobic plate counts; seasonal)
  - seasonal temperature effects (can cause high thermodurics; late-season).

These difficulties can be overcome. A preference for practical trials exists within the dairy industry, but laboratory testing is valuable when used flexibly (as provided for in the standards set by the International Dairy Federation [IDF]), and when the following criteria are fulfilled:
- organisms used in laboratory testing are representative of the range of the organisms causing spoilage and endangering safety
- laboratory conditions are as close as possible to practical use conditions
- comparison is made with standard sanitisers which are of similar type to that which is under test and are known to be effective under practical conditions (the limited range of standards means that secondary standards may have to be employed).

**STANDARDS FOR SANITISERS**

Methods for testing sanitisers are given by the New Zealand MAF (29); the reader is also referred to other recognised publications, such as those by the IDF or national and international standards associations.

**Non-toxicity** is tested by reference to criteria issued by the World Health Organisation (46) or, usually, cross-referenced to the United States Food and Drug Administration (USFDA) Code of Federal Regulations positive lists (45) and procedures (44), or equivalents.

**Purity** is tested in accordance with the *Food Chemicals Codex* (1), and values are adjusted to make allowance for a reduced level of contact.

**Adverse side effects** are covered by a number of publications. Methods of testing for taint, corrosion and inhibition are presented in the MAF publication cited above (29). In addition, methods and reviews of testing for corrosion by immersion and immersion/emersion are given by the IDF (21, 22, 25). Methods of testing for inhibition have also been described by several authors (12, 13, 35, 36, 37), although the MAF methods (29) are to be preferred.

A large variety of standards and methods of testing for **efficacy** is available.

Farm field trial visual inspection, rinse method and swab method are described (29), and other procedures include those of the IDF and MAF (23, 24, 41).

Laboratory sanitiser tests may be performed by comparing the action of the relevant sanitiser on various representative groups of microorganisms with the performance of hypochlorite (at 200 ppm) or a chemically similar secondary standard; a reduction
of 100,000x should be allowed for solutions used on hard surfaces. Various organisations have proposed standards for action against different groups of microorganisms, as follows:

- *Proteus vulgaris*, *Pseudomonas aeruginosa* and *Staphylococcus aureus* (New Zealand Standards Association);
- *Escherichia coli*, *P. aeruginosa* and *Staphylococcus aureus* (Australian Standards Association);
- selection of Gram-negative and Gram-positive bacteria, e.g. *E. coli*, *Streptococcus lactis*, *Pseudomonas fluorescens* and *Staphylococcus aureus* (IDF).

In addition, sanitiser capacity tests are available. The general model is described by the IDF (18), with national variants described, e.g. according to Australian (2) or New Zealand standards (33).

Similarly, sanitiser suspension tests are described by the IDF (19), with variants available according to British standards (modified method) (29).

New European norm sanitiser tests are recognised (3, 4).

Procedures for combined testing of cleaning and antibacterial action on surfaces generally rely on the IDF 'tube' test (20), and variations include a provisional European normative publication (8).

**NEW ZEALAND REQUIREMENTS FOR DISINFECTION OF MILKING EQUIPMENT AND THE SURROUNDING AREA**

New Zealand requirements for disinfection of milking equipment and the surrounding area are described in the New Zealand Dairy Industry Hygienic Design and Layout of Farm Dairies Code of Practice (NZCP3) (6), and include the following:

- milk-contact surfaces should be swept and of free-draining design
- air-lines and milk-lines should be separated
- safe, impervious materials should be used (including stainless steel AISI 300 series)
- safe methods of fabrication
- surfaces should have a smooth finish to 1 μm Ra
- safe installation procedures
- provision for easy inspection
- filtration before primary cooling
- controlled hot water (volume and temperature), minimum use temperature and flow rates
- controlled pumping.

With regard to the disinfection system, NZCP3 sets partial limits on corrosion potential of the disinfectant used, and on the use of increased quantities of disinfectant solution to clean greater milk-line bores and volumes.
With regard to the surrounding area, requirements in NZCP3 include the use of suitably durable and cleanable surfaces, adequate drainage and environmental conditions which support sanitation of the dairy.

It should be noted that functional standards for milking machines specify pulsation profiles and liner fit which, together with post-milking teat disinfection, provide control of mastitis incidence (28).

REQUIREMENTS FOR DISINFECTION DURING MILKING PROCEDURES

Milking procedures must meet the requirements of the Farm Dairy Code of Practice (NZCP1) (7) which relate to primary and secondary cooling and steps in cooler cleaning, as well as general rinsing, washing and sanitising.

Pre-milking teat sanitation is not included. The milking plant and surrounding area are inspected annually for compliance with the food hygiene requirements of NZCP1; failing this, the appropriate quality assurance systems are audited.

General

In New Zealand, milking machines are almost entirely cleaned ‘in-place’, followed by inspection and manual or periodic cleaning, as necessary.

The ‘jetter/third line/recirculation’ cleaning system illustrated in Figure 1 is used in 80-85% of open-air dairies, while the remainder use ‘bucket’ cleaning (bucket/cup/milk-line) and the ‘reverse flow’ system developed in New Zealand (no longer recommended in NZCP1). Recirculation has obvious economic and environmental advantages. Control of the flow rate through jetters is a critical point, with 3-4 l/jetter/minute being required (9).

Routine cleaning requirements

Guidelines given in dairy industry codes with regard to routine cleaning include the following:

- flushing to clear milk residues
- use of approved detergents/sanitisers in accordance with the instructions of the manufacturers
- rotation, e.g. between the following systems:
  a) use of hot, general-purpose acid detergent sanitiser (e.g. phosphoric/sulphuric acid; pH > 2, usually QAC up to 200 ppm)
  b) use of hot, general-purpose alkaline detergent (pH < 12.5; possibly chlorinated, especially for less frequent cleaning), followed by general purpose sanitiser (pH > 2, iodophor [32]/QAC/other).

Rotation usually involves a) for six mornings (or days) and b) for one day. Temperature requirements are 75°C water for the detergent solution, 65°C for the equipment solution discard and 55°C for the bulk milk-tank solution discard (15).

In such a rotation system, where procedure a) dominates, extra sulphuric acid is sometimes used.
The system may also use a cold-water acid detergent sanitiser, usually at approximately twice the normal concentration (limit 200 ppm), but this is now uncommon, as it loses the advantage of the important effect of temperature (16, 14). There is interest in returning to a more equal share of hot alkaline cleaning in preference to mostly acid sanitising.

**Periodic cleaning**

Periodic cleaning removes soilage which has accumulated despite repeated routine cleaning. It uses 3-10 times stronger acid and alkali concentrations (pH < 2 or > 12.5). This resembles factory cleaning of heat-set soilage, except that nitric acid is not used because of corrosion potential (farm rubber and AISI 304 stainless steel) and because of residue concerns.

**Safe rinsing and residues**

Detergent residues are controlled by free drainage and rinsing.

Sanitiser residues are controlled by free drainage. These should also be controlled by application of a pre-milking rinse with safe water only (cf. safe residue clearance similar to USFDA regulations [44, 45], and relatively small reduction [47% to about 0.5 ppm] of QACs on rinsing during combined machine and bulk milk-tank treatment) (40). Rinse reduction is approximately tenfold, but the effect depends on design, porosity, tendency to cling and the method used. Cumulative treatment levels from non-rinsed volumes of sanitiser used are low in relation to acute and other toxicity. The risks are such that water should only be used when treated to a safe level; for this to be effective, the water should be low in organics and reducible substances (10, 31, 35).
Historic development

Prior to the introduction of stainless steel or equivalent materials in 1975, cleaning was performed using the ‘alkaline’ system and approved ‘triple system’. The former system employed the following stages:

- pre-milking iodophor and post-milking rinse
- hot mild alkaline wash.

The triple system added a boiling water rinse as the third stage.

The acid sanitiser system has changed due to greater recognition of the microbiological risks involved in rinsing and increased rotation with alkaline systems.

Numerous studies have been conducted on the effects of water (43), iodophors (38), milking systems (31, 42), simulation (11) and soiling (34).

At present, cleaning makes increasing use of air injection for increased turbulence and some reduction in the concentration of sanitising solutions (39). Consideration of the importance for milk quality of somatic cell counts and cattle health has recently increased in New Zealand, in line with practice in other countries and reduced contamination from equipment. Milk-lines in New Zealand are traditionally placed in a relatively high position, but this is changing to enable the use of less severe vacuum levels and therefore reduce strain on udders. Together with improved liners and adjustable pulsation, this will improve cattle health and sanitation. The most recent developments which will have an effect are airless milking, automatic cow identification and data recording.

Sanitisers for farm milk-contact surfaces have mainly been limited to chlorine, iodine and QACs. Detergent sanitisers are most common, as they are convenient and because acid and heat for cleaning also assist the antibacterial effect of QACs. The concentrations, and expansion in the range of sanitisers, are in line with changes in United States registrations (44, 45).

Teat sanitisers and related applications

The use of teat sanitisers in New Zealand is regulated by the Animal Remedies Act 1967 and similar provisions in the Pesticides Act. Use/residue surveys confirm that hazards are controlled, i.e. that preventive/registration systems are working effectively under these regulations. Surveys also show that New Zealand systems are generally simplified by reduced vector risk, opportunity for reduced therapy, and opportunity for therapy in the dry period outside the herd lactation period.

Teat sanitisers provide therapy which should be effective within confidence limits, and which should ensure safety of animals and consumers when used in accordance with label instructions. A bactericidal effect test was modified and used with excised teats at the National Dairy Laboratory. Approximately 65% of herds are treated. Of these, 70% are treated using iodophors, 15% using chlorhexidine and 15% using linear dodecylbenzene sulphonate.

Use concentration varies by a factor of approximately two, depending on increase in risk during the early/wet season.

TESTING SYSTEMS

Testing systems used in New Zealand are at least as good as those required by the relevant standards.
General sanitation testing includes the following measures:
- self-check at milking (in accordance with the Farm Code [NZCP1])
- annual external check by second or third party (in accordance with the Inspection Code [NZCP3]) or quality system audit.

These measures ensure that the plant and environs are visually clean, and that equipment, materials, installation and environs are within hygiene specifications.

The following tests are also performed:
- standard plate count or continuous flow epifluorescent microscopy (every 10 days; penalty limits 100,000 and 200,000 colony-forming units [CFU]/ml)
- for coliforms (every 30 days; advisory limit 100 CFU/ml)
- for thermodurics (every 30 days; advisory limit 5,000 CFU/ml).

CORRECTIVE ACTION SYSTEM

Any suspect milk quality result is automatically verified. Effective traceback and correction of problems are also practised, and the procedures have been described (17). Contamination, infection and diagnosis are affected by season and lactation. Diagnosis is also affected by the sensitivity of tests and rapid tests to different bacterial classes, such as pathogenic streptococci (27).

PENALTIES AND PROHIBITIONS FOR NON-COMPLIANCE WITH SANITATION REQUIREMENTS

Within the dairy industry in New Zealand, a system of penalties and prohibitions is operated to provide practical control of health safety factors.

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UTILISATION DES DÉSINFECTANTS DANS L'INDUSTRIE LAITIÈRE EN PLEIN AIR. – R.E.J. Hutchinson.

Résumé : Les systèmes de désinfection sont essentiels pour offrir des produits laitiers propres à la consommation de toutes les catégories et groupes d'âge de la population humaine.


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EL USO DE DESINFECTANTES EN LA PRODUCCIÓN LECHERA AL AIRE LIBRE. – R.E.J. Hutchinson.

Resumen: Es esencial contar con sistemas de desinfección si se quiere ofrecer productos lecheros aptos para el consumo de todas las categorías y las clases de edad de la población humana.

La competencia en materia de calidad en la industria lechera neozelandesa se lleva a cabo respetando, por una parte, las normas de los sistemas generales (ISO9002 y ISO Guía 25) de la Organización Internacional de Normalización (International Organisation for Standardisation: ISO) y, por otra, la legislación nacional que asegura la inocuidad de los alimentos (reglamento de 1990 sobre la industria lechera). Esta última requiere la producción de los alimentos sanos en conformidad con los programas de protección alimentaria aprobados por el ministerio de agricultura y pesca. La inocuidad de los alimentos puede garantizarse si se respetan los códigos de buenos procedimientos de la industria. Los detergentes y los productos para el saneamiento de las granjas lecheras deben ser aprobados. El autor describe estos sistemas de desinfección.


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REFERENCES


