THE HANDLING OF MILK

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It is an old saying that nature never intended milk to see the light of day, and as our knowledge of milk hygiene increases the more truth there seems to be in this statement. Milk is a highly nutritious fluid and therefore readily subject to attack by a great variety of micro-organisms. Hence it is desirable that it should be kept free from contamination by micro-organisms carried on dust particles and other air-borne debris. The vitamin content of milk is subject to partial destruction by even a small exposure to direct sunlight or diffuse daylight. Thus, the main object in handling milk in the dairy barn should be to transport it quickly to the milk-room, cool it immediately, and keep it cold in a closed container until ready for dispatch. By this means the chemical and bacteriological properties of the milk will be best preserved.

Care in handling milk starts in the cowshed; therefore those aspects of milking procedure which might influence the bacteriological quality of the milk will be considered here.

Udder Washing

Frequently the coat of the milking animal is clean before milking and consequently little or no attention is given to the cleaning of the udder. It is desirable, however, that the udder of each cow should be washed before each milking for three reasons: firstly, to minimize the spread of mastitis from one animal to another; secondly, to keep dirt out of the milk and thereby improve its bacteriological quality; and thirdly, to act as a stimulus to milk ejection or let-down.

In some modern cow-houses, such as parlours or well-milkers, a supply of water is piped to the milking site so that the udder of each animal can be washed by a fine spray of water manipulated by the milker. This is followed by drying with fresh paper towels. This is probably the most satisfactory method of udder washing as it completely avoids the risk of

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passing infection such as mastitis from one animal to the next. However, where such facilities are not available it is reasonable for the udders to be washed with a suitable disinfectant solution in a bucket. Paper towels are highly recommended, but where these are not available cloths or sponge towels can be used. Probably the most convenient method of udder washing using buckets is with two cloths and two buckets. The first bucketful of solution is intended to remove obvious dirt from the udder and the second to clean and disinfect the udder. The liquid in the first bucket should be changed when necessary; in clean dry conditions it may suffice for 6, 8 or even 10 cows, whereas, when the animals come in from wet muddy pastures, it may be necessary to use a bucket of water for each animal. Since this first bucket is needed only to remove dirt, it might seem unnecessary for it to contain disinfectant. However, in view of the ever-present risk of transferring infection by this means from one animal to the next, it is desirable that both buckets should contain disinfectant (except of course where a fresh bucket of water is required for each animal).

There is more than one type of disinfectant that can be used in the water, but sodium hypochlorite at the rate of 500 parts per million (p.p.m.) has proved to be generally satisfactory. Good reports have also been received on the use of quaternary ammonium compounds (QAC's) and other suitable disinfectants. Newbould & Barnum (1958) assessed the efficiency of disinfectants for udder washing by determining the number of microorganisms that could be removed from teat-cup liners by swabbing immediately after the clusters had been removed from the cows. These workers found that increasing the concentration of sodium hypochlorite or iodine solutions had little effect in reducing the bacterial count as determined above. On the other hand, using a chlorhexadine compound, Hibitane, which possesses strong bacteriostatic properties, a definite relationship was noted between the concentration of the solution and the reduction in bacterial numbers.

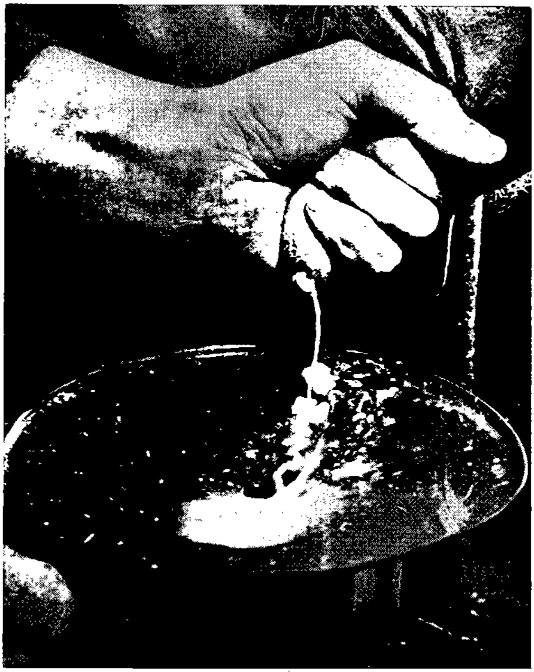
From time to time, it is reported that the use of a certain chemical has caused chaps and cracking of the teat. Such reports are not confined to one chemical alone, and the skin damage may be the result of a number of factors. Frequently a change from one disinfectant to another will remedy the condition.

It is recommended that after the udder has been washed with a wet cloth, the cloth should be wrung out *outside* the bucket, re-wetted, wrung out and then used to remove the excess moisture from the udder. The drying procedure should obviously be more thorough after the disinfectant wash from the second bucket. It is undesirable to leave the udder in a wet condition, as this would allow drops of moisture to get into the milk.

However effective the udder washing may be, it should not be regarded as more than a safeguard against possible infection from unknown mastitis. Where cases of mastitis are known, the spread of infection can be prevented more effectively by segregating the infected animals and milking them last.

Use of the Strip-Cup

FIG. 1
THE USE OF THE STRIP-CUP IN DETECTING ABNORMAL MILK



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Physical examination of the milk for gross abnormality before milking can be helpful not only in detecting early stages of mastitis but also in preventing abnormal milk from getting into the bulk. A high proportion of abnormal milk is known to have an adverse effect on such bacteriological tests as the methylene blue and resazurin tests. The use of a strip-cup (see Fig. 1) can help to detect such abnormalities and is essential for the physical examination of milk. The practice of drawing the fore-milk on to the floor of the barn cannot be too strongly condemned, not only because stale milk smells putrid and attracts flies, but also because milk containing mastitis organisms may be transmitted in this way to other teats of the same cow when it lies down, and sometimes to other cows.

There is evidence to show that the number of micro-organisms in the fore-milk is higher than in the remainder of the milk. It has been suggested by some workers that the bacterial count of milk can be reduced by discarding the fore-milk, but it is doubtful if this has any significant effect. The amount of fore-milk withdrawn is in any case small. Estimates of the reduction in bacterial counts by rejecting fore-milk vary between 1 % and 4 % (Lochhead, 1939).

Disinfection of Teat-Cups during Milking

The practice of dipping teat-cup clusters in a disinfectant solution between milking one cow and the next has been practised probably as long as milking machines have been used. There are, however, doubts as to whether the practice is worth the effort involved and whether it may not do harm by leading to a false sense of security.

However effective the disinfectant solution used, it is necessary to see that no airlocks are formed in the cluster during dipping, otherwise the solution will be prevented from entering the liners when the cluster is submerged. This can be overcome either by removing the long milk tube from the claw-piece (or from the tap on the bucket or pipeline) or by some other similar procedure, such as lifting the lid of the bucket or lifting the tap out of the bucket lid. Nevertheless, even when adequate precautions have been taken to prevent such airlocks, there are still other circumstances that will prevent complete disinfection. The claw-piece of the long milk tube will be wet with milk from the previous animal and some of this milk is bound to drain back into the liners immediately before the unit is put back on the next animal. If the previous animal's milk contained mastitis organisms, there is a possibility that the next animal may become infected.

Taylor & Hoy (1954) published a short synopsis of work carried out during the war on the effectiveness of dipping clusters in a disinfectant solution between cows. When precautions were taken to prevent airlocks, the practice of dipping clusters reduced the percentage of clusters infected with *Streptococcus agalactiae* from 47 % to 8 %. These workers found that while complete immersion of clusters for periods of as much as 5 minutes in a solution containing 2000 p.p.m. of available chlorine was the most effective treatment tried, it could not be relied upon to sterilize teat-cups used to milk cows that were heavily infected with *Str. agalactiae*. The immersion of clusters for 5 minutes during milking would be impracticable, unless spare sets of liners were used. Taylor & Hoy also made the observation that *Str. agalactiae* in naturally infected milk was about 10 times as resistant to hypochlorite as laboratory strains.

It would appear, therefore, that dipping of clusters between cows should be given second place to udder washing and the use of the strip-cup and should not be practised if the time involved is likely to prevent thorough carrying-out of either of these two operations. Segregation of badly infected animals is, of course, the most important consideration of all.

Recent information from the National Institute for Research in Dairying (1959) has shown that, for the disinfection of clusters before milking each animal, application of hypochlorite solution at 87°C to the inside of the teat-cups for 6 seconds is more effective in preventing the spread of mastitis organisms than immersion of the teat-cups in unheated hypochlorite for 1 minute.

Straining of Milk

The straining or filtration of milk causes little or no improvement in its bacteriological quality; in fact, the reverse may be the case. Even with the most modern filtration equipment, the spaces between the fibres of a filter must be considerably larger than the size of bacteria in order that the milk shall filter at a reasonable rate. Therefore, micro-organisms will be able to pass through such filters, and only large particulate matter will be filtered out. The removal of such particulate matter will have the effect of improving the sediment test on milk, but it will not improve the bacteriological quality, because the milk-souring organisms that have the greatest bacteriological effect will pass through the filters. The filtration of milk thus serves two purposes: it can improve the quality of milk from an aesthetic viewpoint, and it can indicate to the producer how much dirt is getting into the milk.

If the metal strainer, which contains the filter pad, has not been adequately cleaned and sterilized, the process of filtration may impair the bacteriological quality of the milk. As milk is filtered in any case at the receiving dairy, there have been suggestions that there is no need for the producer to filter milk before sending it to the receiving depot. Such a practice would prevent the milk from becoming contaminated by contact with an additional, perhaps unsterile, surface, and it would also afford the receptionist at the dairy an opportunity to determine which milk had been produced under satisfactory conditions. Straining of milk is perhaps more of a traditional than a logical procedure. It was obviously very desirable in the days of hand milking when milk was distributed directly from a great number of farms to the consumer. With hand milking, and particularly wet hand milking, considerable quantities of dirt and particulate matter did get into the milk. At the present day, with machine milking, provided that udder washing is carried out satisfactorily, there should be little extraneous matter in the milk. Filtration will, of course, remove the clots from bad mastitis milk, but such milk should be detected by the use of the strip-cup, and should be excluded from the bulk. With pipeline milking, specially designed filters are placed in the milk pipeline. These, however, do little more than supplement the information already provided by the strip-cup. Further, they are an additional piece of equipment which has to be cleaned and sterilized, and their value is therefore open to question.

Cooling

The scientific reason for the cooling of milk is to keep it in a bacteriologically stable state. No matter how clean the methods of milk production are, some micro-organisms will get into milk, and it is desirable to prevent these from growing and multiplying. Obviously, with unsatisfactory methods of production the number of micro-organisms getting into milk may be excessive. Under these conditions the value of cooling will be greater. This information can be readily appreciated from the table. With sample A the bacteriological quality after 22 hours with very little cooling (i.e., to 65°F(18.3°C)) was still reasonably satisfactory and almost as good as that of sample C held for the same period at a temperature of 40°F

EFFECT OF STORAGE FOR 22 HOURS AT DIFFERENT TEMPERATURES ON THE COLONY COUNT AND KEEPING QUALITY OF THREE RAW-MILK SAMPLES OF DIFFERENT INITIAL BACTERIOLOGICAL QUALITY *

Storage temperature (°F)	Storage temperature (°C)	Sample A		Sample B		Sample C	
		Colony count (30°C)	Keeping quality at 18°C (hours)	Colony count (30°C)	Keeping quality at 18°C (hours)	Colony count (30°C)	Keeping quality at 18°C (hours)
40	4.4	1 900	46	41 000	38	270 000	24
50	10.0	1 720	44	48 000	34	740 000	20
60	15.6	15 000	40	110 000	26	17 000 000	8
65	18.3	500 000	26	2 420 000	18	58 000 000	4
70	21.1	1 700 000	22	16 600 000	6	200 000 000	Sour

* After Thiel (1948)

(4.4°C). On the other hand, failure to keep sample C cool for 22 hours resulted in souring of the milk.

The following tabulation shows the effect of different storage temperatures on the methylene-blue dye-reduction test of aging milk at different temperatures.

Storage temperature (°F)	*(°C)*	*Alteration in reduction time for every 30-minute increase in storage up to 5 hours (minutes)*
41.0	5	−2.2
50.0	10	0
59.0	15	2.0
68.0	20	8.2
77.0	25	13.3
86.0	30	19.9
95.0	35	23.4

A temperature of 50°F (10.0°C) will maintain the milk in a bacteriologically stable condition for a period of about 5 hours (Smythe, 1945). At temperatures above this, the milk will deteriorate according to the temperature at which it is stored, but at a temperature below 50°F (10.0°C) the milk actually improves with respect to the result of the methylene-blue reduction test.

The value of milk cooling, therefore, depends to a very large extent on the temperature to which the milk can be cooled. This is frequently governed by local circumstances. Where non-refrigerated coolers are used, i.e., those in which the coolant is the farm water-supply, the water temperature may sometimes approach 70°F (21.1°C) in summertime. There is no doubt that going through the motions of cooling with water at that temperature is of no benefit whatsoever. Moreover, unless cooling is done inside the milk-can, it probably does more harm than good by bringing the milk into contact with another surface. Every attempt should be made to ensure that the water itself is kept as cool as possible; such obvious measures as insulating tanks in the milk-room, lagging pipes leading to the cooler, or seeing that a pipeline from a spring does not get heated up by the sun, are simple but are frequently neglected. Some farms have two supplies of water, yet only one may be sufficiently cool. Provided that it is not badly contaminated, every effort should be made to use this supply for cooling.

There are two methods of cooling that can be used with a farm-water supply, surface cooling and in-can cooling.

Surface-coolers

Surface-coolers (see, for examples, Fig. 4 of chapter by Rice, page 476, and Fig. 3, 4 of chapter by Anquez & Tiersonnier, pages 551, 552) may be water-cooled or refrigerated; the refrigerated type may employ either the direct expansion system, where the primary refrigerant is expanded in the tubes of the heat exchanger, or the indirect system, in which a secondary coolant, frequently brine, acts as a vehicle to convey the heat from the milk to the refrigerant vapour.

The corrugated cooler. This is a very efficient water-cooler with a single-pass counterflow for water. A water flow at approximately 3 times the rate of the milk flow will lower the temperature of the milk to within about 3°-4°F of the water temperature. This type of cooler is not suitable for other than very low water pressures (about 5 pounds per square inch (p.s.i.) or 0.35 kg/cm^2).

The corrugated tubular pressed cooler. Two pieces of corrugated metal are welded together back-to-back along the ridges and end-pieces are fitted, so that there is one continuous tube for the coolant to flow in. This type of cooler will withstand higher pressures than the non-tubular type of cooler but is not used as an evaporator with primary refrigerants.

The tubular seamless cooler. This is made out of properly fabricated tubes with vertical spacers. This type of cooler is capable of withstanding pressures of 200-250 p.s.i. (14-17.5 kg/cm^2) and can be used with a refrigerant.

The drum cooler. This type of cooler consists of two stainless steel cylinders, 6-8 in. (15-20 cm) in diameter. These are positioned one above the other and connected with a vertical spacer. The upper cylinder is for pre-cooling with water, and the lower cylinder for final cooling with a primary refrigerant.

In-can cooling

Immersion cooling. For this purpose, all that is needed is an insulated tank in which the cans are immersed up to the level of the milk (see Fig. 12 of chapter by Blodgett, page 139). In northern temperate countries the temperature of the water may be sufficiently low all the year round to cool the milk. In countries where ice is available in the winter it may be harvested and stored in ice-houses or ice-wells for use in the immersion cooler during the summer.

Cooling in such tanks is slow, unless there is agitation of the milk, and nowadays this is usually performed mechanically. The inversion point of water occurs at approximately 39°F (3.9°C) and below this figure the density decreases with falling temperature. It follows, therefore, that convection currents set up in a water tank at 35°-40°F (1.7°-4.4°C) will be extremely sluggish. The water in the vicinity of the cooling surfaces of the evaporator being cooled to around 33°F (0.6°C) will have a slight tendency to rise because its density is less than the maximum, and water in the proximity of the milk cans being at approximately 50°F (10.0°C) will also tend to rise. Thus mechanical agitation of the water is very desirable. Without agitation water at 35°F (1.7°C) will take 200 minutes to lower the temperature of milk from 90°F (32.3°C) to 50°F (10.0°C); however, with agitation the same process will take only 90 minutes. It can be greatly speeded by mixing the milk.

One of the difficulties with immersion coolers is the weight of a full can of milk. Cans of above 8-gallon (about 36-litre) capacity are very difficult to handle. For example, a full 10-gallon (45-litre) can will contain 103 lb. (47 kg) of milk, and, unless it is made of aluminum, the empty can will weigh about 33 lb. (15 kg). Obviously some form of mechanical lifting for this 136 lb. (62 kg) would be desirable.

Cascade coolers. The simplest type of cascade cooler is a sparge ring (see Fig. 2; see also Fig. 5 in chapter by Anquez & Tiersonnier, page 552).

FIG. 2

AN IN-CHURN MILK COOLING INSTALLATION USING A CHILLED WATER COOLING UNIT

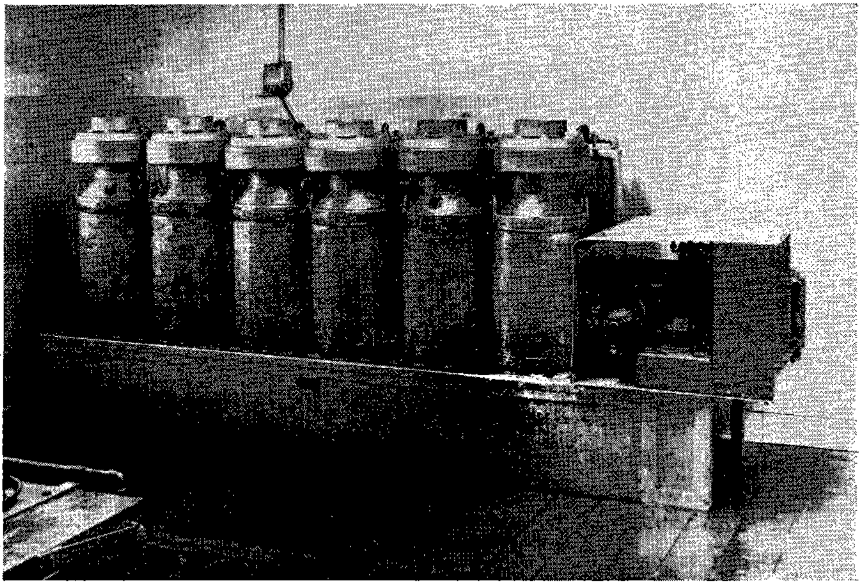

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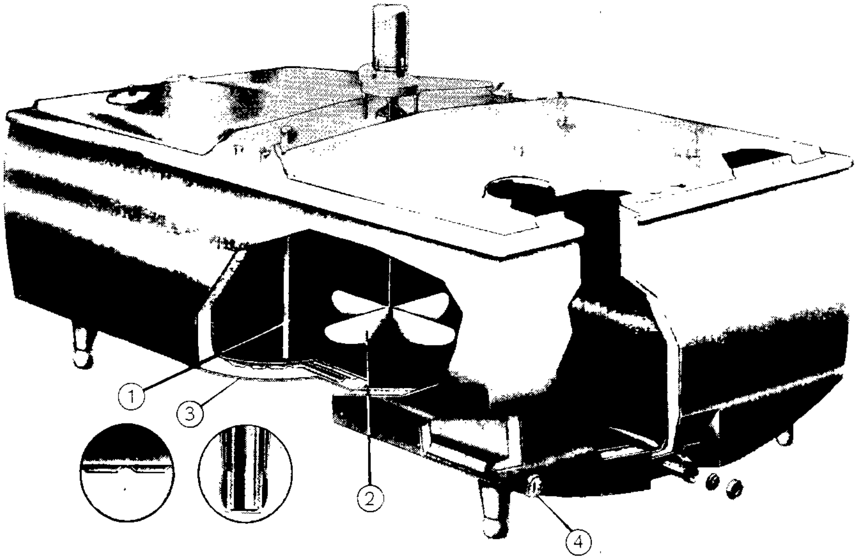
FIG. 3
DIAGRAM OF BULK MILK TANK



1 = Milk measuring gauge
2 = Impeller
3 = Refrigeration channels and insulation in wall of tank
4 = Dial thermometer

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This is merely a tube with holes in it which is bent into a ring and fitted around the neck of a can; the water flows out through the holes and over the outside of the can. If unchilled water is used, a plentiful supply will be needed, because it must either go to waste or be used for cattle drinking. If the water can be cooled mechanically, it should be in a closed-circuit system, possibly with an ice-bank to allow a small compressor to be used. Refrigerated cascade coolers have a slightly better cooling rate than agitated immersion coolers. A 10-gallon (45-litre) can with a cascade cooler will be cooled from 90°F (32.2°C) to below 50°F (10.0°C) in 50-60 minutes, where the water temperature is 35°F (1.7°C).

A more recent type of cascade cooler embodies a turbine stirrer, and a still more modern type has a slowly rotating, tubular water-circulating element, which is immersed in the milk, the overflow from this element being allowed to flow over the can as a film.

Bulk coolers

Only a limited description of this type of cooler will be given here, as there are many makes and the manufacturers' brochures are quite detailed (see Fig. 3). Furthermore, this type of cooler is expensive to install, and its full advantages cannot be utilized unless milk is collected every other day with a bulk pick-up tank.

Bulk-cooling tanks are of two types: (*a*) gravity-filled tanks which are at atmospheric pressure, and (*b*) vacuum tanks, in which the vacuum is maintained by a pipeline milking machine. Two systems of refrigeration are used, the ice-bank, and direct expansion of the refrigerant.

The ice-bank system requires a compressor working 80 % - 90 % of the time. With direct expansion, a larger compressor is needed but it works for only 25 %-30 % of the time. Air-cooled compressors and condensors are designed in the ratio of 1-HP compressor to 100 gallons (450 litres) of vat capacity. A 200-gallon (900-litre) direct-expansion tank with daily pick-up of the milk will require a 2-HP compressor, but if the milk is picked up every other day a 1-HP compressor will be sufficient. The direct-expansion type of cooler costs more than the ice-bank to install, but less to operate, because the ice-bank type has a circulating pump. Vacuum tanks may have some advantage because they remove some feed odours from the milk as the milk is cooled under vacuum, and, in addition, they are dust-proof.

Milk comes into the tanks at 92°-98°F (33.3°-36.7°C). Most tanks cool the first milking to 36°F (2.2°C) in 1½-2 hours. With subsequent milkings the milk is cooled more rapidly, because there is a greater surface area of the cooler in contact with the milk and because the already cooled milk acts as a reserve of cold. The maximum temperature of the blend will be about 45°-50°F (7.2°-10.0°C). Nevertheless, the amount of heat to be removed is about the same as in the previous milking; consequently, the time required to reduce the temperature to 36°F (2.2°C) would be about the same were it not that the surface area of the cooler is effectively increased.

Conclusion

When milk has been produced and efficiently cooled it is obviously logical to see that it is maintained in a cool condition until it reaches the dairy. With bulk-tank collection this is seldom a problem, because the bulk pick-up tanks are adequately insulated. In some countries, the pick-up trucks are covered or even refrigerated, particularly where long hauls are necessary. However, there are all too many occasions where hauliers do not take sufficient care even to provide a tarpaulin cover or canvas to cover the cans. In some areas, they may have little encouragement to do so, because farmers frequently leave the milk on stands by the roadside in the direct glare of the sun. There is obviously a need for properly constructed and shaded milk stands. Clearly, the co-operation of both the producer and haulier is essential if milk is to reach the dairy in a sufficiently cool condition.

REFERENCES

Lochhead, A. G. (1939) *Introducing clean milk* (Canadian Department of Agriculture Publication No. 524)
National Institute for Research in Dairying (1959) *Annual report* . . ., Reading, Lamport Gilbert & Co., Ltd.
Newbould, F. H. S. & Barnum, D. A. (1958) *J. Milk Tech.*, **21**, 306
Smythe, V. R. (1945) *Qd J. agric. Sci.*, **1**, 1
Taylor, M. E. & Hoy, W. A. (1954) *J. appl. Bact.*, **17**, ii
Thiel, C. C. (1948) *J. Soc. Dairy Tech.*, **1**, 199