MILK COOLING — AS YOU FIND IT*

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A study was made of the factors influencing the temperature of milk delivered to Erie County, New York, processing plants under existing local conditions. One of the most interesting facts developed was that even with ideal transportation facilities there were wide changes in the temperatures of 40-quart cans of milk and these changes could be predicted for any market. It also re-emphasized that low quality milk needs lower cooling temperatures than high quality milk.

This study was a practical approach to the problems of the cooling of milk at the farm and temperature changes during transportation to the milk plant. It was undertaken: (1) To determine, under practical conditions, the most effective temperature for the cooling of milk at the farm; (2) To gain further information on the factors influencing the temperature of milk as delivered to the milk plant under existing conditions in the Erie County market.

Although legal requirements for the cooling of milk vary in the maximum allowable degree of temperature to which milk must be cooled at the farm, there is general agreement that the maximum temperature should be from 50°F to 60°F. There also appears to be general agreement among health authorities that maximum allowable temperatures above 60°F or below 50°F are not feasible. For that reason this study emphasized the temperatures within the 50-60°F range.

A study by Bruckner1 in 1938 indicated that good sanitary quality milk need only be cooled to 60°F to preserve its quality, while milk of lower sanitary quality should be cooled below 50°F to prevent marked bacterial growth.

Bruckner concluded in his study "that within certain limits cooling is not as important with good milk as it is with milk that contains a comparatively large number of bacteria before cooling is started. He also stated, "It is fairly safe to assume that when counts get above 50,000 to 100,000, improper cooling is indicated in addition to perhaps poorly washed and sterilized equipment." Since many of the bacterial counts in the Erie County study exceed these counts, it would be logical to expect that some of the temperatures encountered in this study would have a direct effect on the bacterial population.

A study of "The effects of farm cooling methods and transportation on the temperature of night's milk" was made by S. Abraham and C. H. Outwater2 of the New York City Department of Health in 1942. In this work temperature changes during delivery were found to produce an overall rise in the average temperature. They reported the average temperature of all night milk at the farm was 47.8°F with an average rise in temperature on uniced trucks of +4.4°F to 52.2°F during delivery. Similar data was also compiled when ice was used during transportation. These data showed an overall average rise in temperature of +0.1°F during transportation with a range of -4°F to +7°F. It should be emphasized that the New York City study dealt with various types of truck bodies.

METHODS

In this study 385 dairy farms on 18 different loads of milk were selected at random for study. The maximum legal temperature for cooling in the district is 60°F. Morning milk is cooled as well as night milk, inasmuch as a considerable portion is delivered after a 10 a. m. deadline. 97 percent of the milk producers in the area use mechanical coolers and a like percentage are equipped with milking machines. The study was carried on during the "warm weather" period of June, July, and August, with the temperatures during delivery hours ranging from 40°F to 80°F.

In this study only closed-type truck bodies without refrigeration (in general use in the market) were used, and all milk was presumably "cooled" milk. These conditions of course minimized or eliminated some of the variable factors you would encounter such as icing, type of truck body, outside temperatures.

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Milk Cooling

Complete data were collected on each load of milk studied. Temperatures of night and morning milk were taken as the milk was picked up at the farm. Other data collected at the time of pickup included air temperature, cooling medium temperature and time of day. The load of milk was then escorted to the milk plant and temperatures of night and morning milk were re-taken, and samples collected for direct microscopic examination. In order to minimize errors in comparisons between individual farms, each farm was given a good, fair or poor rating on the basis of cleanliness of milk contact equipment. This rating was made by the inspector regularly assigned to the inspection of each farm. In this way, we avoided comparing good farms with farms in the other two classifications (fair and poor) where such comparisons might be affected by the thoroughness of cleaning. Although this method of classification of dairy farms may not be absolutely accurate, it may be considered generally good since the ratings were made by individuals in intimate contact with the sanitation on each farm over a considerable period of time.

No attempt was made to compare the cooling medium with milk temperature because the temperature of the cooling medium was found to depend on the elapsed time between milking time and time of pickup. It was noted that morning milk picked up within an hour after milking was not cooled as much as milk collected later on. The temperature of night milk in the cooling vat was also affected in varying degrees by the elapsed time between milking and pickup.

Comparative figures in this study showed the average temperature of all milk at the farm to be 47.84°F; the average delivered temperature being 50.66°F, thus giving an overall average increase in temperature of +2.82°F rather than an increase of +4.4°F found in the New York City study. The following temperature groupings of the milk in this study were as follows:

- 8.9% all cans 61°F, or higher at farm
- 5.5% all cans 61°F, or higher at plant
- 22.5% all cans 59°F, or higher at farm
- 24.0% all cans 59°F, or higher at plant
- 30.0% all cans 51°F, or higher at farm
- 50.0% all cans 51°F, or higher at plant

These figures show that with a legal maximum temperature of 60°F, when temperatures are taken on deck, only 5.5 percent of the cans would have been rejected, although 8.9 percent of the cans were above 60°F, when they left the farm. Obviously no dairy farmer would have milk rejected on the platform which had been cooled to 60°F or lower at the farm. This condition does not hold true with legal maximum temperatures of 55°F or 51°F, since a greater percentage of milk were above those temperatures when received at the plant. Using a 55°F temperature limit the plant inspector would find 24 percent rejectable at the plant although 22.5 percent was actually cooled within that limit when the milk left the farm. Likewise with a 51°F temperature limit the efficiency of cooling on the farm would not be properly reflected by the can temperatures at the receiving plant.

STUDIES

A comparison of the temperature changes on milk trucks with varying amounts of time consumed during delivery showed little difference. The average elapsed delivery time for the 18 truckloads studied ranged from 2 hours to 4 hours. The shortest haul showed the same average temperature changes as the longest haul. In other words the usual temperature changes took place within the 2 hour period.

In this study of the rise and fall in milk temperatures between the farm and milk plant, all cans of milk were included. No segregation of a. m. and p. m. milk or good or poor farms is made since these factors do not affect the temperature changes of the milk during delivery.

In Table 1 the actual number of all 40-quart cans of milk picked up at the farm at each degree of temperatures from 35° to 65°F is listed together with the average temperature of that milk upon delivery at the plant. For example, there were a total of 20 cans of milk which tested 45°F at the farm and the average delivered temperature of all those cans of milk at the milk plant was 41.5°F or an average rise of 0.5°F, for each can of milk. In examining this table you find that 45°F milk on the farm rose an average of 3.4°F with corresponding increases in temperature until a point between 53° and 54° where an end point is reached and the milk starts to decrease in temperature. Milk at 55°F when picked up at the farm shows an average decrease in temperature of 0.8°F upon delivery, while milk at 60°F shows an average decrease in temperature of 2.7°F.

Graph No. 1, on separate sheet, depicts this relationship between temperatures on the farm and the change in temperature during delivery. Since outside factors have been eliminated or, at least, minimized, it is our belief these temperature changes are almost entirely due to the transfer of heat between the cans as they stand in the truck. From this graph we can predict, with some accuracy, the temperature of a can of milk upon delivery when the farm temperature is known.

Under the conditions of this study, we can, for instance, forecast that 60°F milk on the farm will reach the plant at 57°F and 65°F milk will deliver at 60°F. This means that under the present conditions, poor cooling will be
covered up during transit by the transfer of heat to well-cooled cans of milk.

With a 60°F temperature regulation (as in Erie County) 94.5 percent of the milk reaching the milk plant was of legal temperature, but of the temperatures taken at the farm only 91 percent of the same milk was of legal temperature.

You will note in Graph No. 1 there is a tendency toward a leveling off of the curve in the vicinity where decreases in temperature change to increases (53-54°F). In order to obtain a magnified picture of the curve in the vicinity of the milk reaching the milk plant was of legal temperature. Group No. 2, was prepared. This graph deals with farm temperatures of 49°F to 60°F plotted against the average delivered temperatures. You will notice that part of the curve in the critical area is boxed off.

In Graph No. 3, 3° temperature groups were used in order to avoid the distortion of extremes in temperatures, which are more pronounced in 1° temperature groups. As in Graph No. 2, farm temperatures are plotted against the average delivered temperatures. This graph magnifies the leveling off portion of the curve in the 53° to 55° area.

In order to depict the changes which occur between the temperatures in common use as legal maximums, Table 2 was prepared. It shows the number of temperature group changes which resulted from transporting the milk from farm to plant. Group 1 50°F or less; Group 2 51-55°F; Group 3 56-60°F; Group 4, over 60°F. In the lowest temperature group (No. 1 50°F or less) there were the fewest group changes, while the greatest number of changes were found in Group No. 2 (51-55°F). This was to be expected inasmuch as this temperature group includes the critical temperature area where we have both increases and decreases in temperature. In Group 4 (over 60°F) the number of changes was also large. This reflects the marked cooling effect on high temperature milk, a major portion of which was within a 61-65°F range.

FARM TEMPERATURES COMPARED WITH BACTERIAL COUNTS OF MILK DELIVERED TO MILK PLANT

In this study the good, fair, and poor classifications of dairy farms based on cleanliness of equipment was used in order to make comparisons between farms of equal quality.
In Table 3 the group temperatures of milk on the farm are compared with the direct microscopic counts. This comparison is broken down to show the effect in good, fair and poor dairy farms. The direct microscopic counts are grouped as follows: Group I, 200,000; Group II, 200,000 to 500,000; Group III, 500 to 1,000,000; Group IV over 1,000,000. You will note that in Group I temperatures (50°F or less) over 76 percent of the bacterial counts were under 200,000 per ml while poor farms show only 58 percent and 40 percent respectively. The same relationship exists in temperature groups II and III. These results indicate that the bacterial counts are more closely related to the actual milk temperature under the conditions of the experiment. A summary of the Group I direct microscopic counts is contained in Column 1 of Table 3. These figures show clearly that the percent of direct microscopic counts in Group I (below 200,000) remain constant regardless of the temperature group. However the percent of bacterial counts for temperatures over 60°F (Group IV) are higher than for temperatures below 60°F.

Further compilations were made to determine the effect of comparing temperature of milk as delivered to the plant (rather than the farm temperatures) with the bacterial counts. It was found that no significant differences existed in this comparison that were not shown by the comparisons of farm temperature vs. bacterial counts.

**Comparison of the Temperatures and Bacterial Population**

For this comparison, only farms rated as “good” were used inasmuch as this was the largest single classification. These results are shown in Table 4.

You will note the direct microscopic groupings for each temperature group are about the same regardless of the temperature. Hence, no significant rise in bacterial counts can be traced to the higher temperatures encountered in this study. This may, in part, be explained by the fact that morning milk temperatures were generally higher, but the age of this milk on delivery was not great enough to permit appreciable bacterial growth.

**Conclusion**

1. Within a temperature limit of 60°F the bacterial counts of milk as delivered to the milk plant were not materially affected by the temperature of the milk. Milk cooled to 50°F or below, and milk cooled to 55°F did not show any improvement in bacterial count over milk cooled only to 60°F.

2. Dairy farm ratings of good, fair, and poor classifications made by the dairy farm inspector and based on the efficiency of cleaning and disinfection of milk utensils are directly related to bacterial population. Generally speaking bacterial counts increased as farm ratings decreased.

3. Under the conditions of this study, milk at 53°F or lower on the farm will increase in temperature during transportation, while milk at 54°F or higher will decrease in temperature during transportation.

4. Temperatures of milk taken at the receiving plant do not necessarily reflect the efficiency of cooling on the farm.

**References**
