procedure for removing surface bacteria has been indicated by Koons. Miller and Goresline *et al* have reported a substantial decrease in bacterial contamination and an increase in shelf life by the use of low concentrations (10 to 20 ppm) of chlorine in the processing and chilling water.

Kohler *et al* were able to increase shelf life of chilled poultry by the addition of 10 ppm of the antibiotic *chlortetracycline* (*aureomycin*) to the water used to chill the eviscerated carcasses. Both *chlortetracycline* and *oxytetracycline* have been proposed by producers of these antibiotics, and approved by Food and Drug Administration as additives to poultry chilling water. Many studies in laboratories and in commercial processing plants have been made in order to appraise the usefulness and safety of this practice. Permissible amounts of chlortetracycline in the chilled poultry carcass have been limited by federal regulations to seven parts per million, and it has been shown that much greater concentrations than this are completely destroyed during normal cooking. Experimental results and conclusions on the amount of extended shelf life provided by the use of these antibiotics vary somewhat. However, different storage temperatures were used, initial bacterial loads probably varied between studies, and not all investigators determined the actual amounts of antibiotic introduced into the meat during the chilling or soaking period, Kohler *et al* found at least seven days additional shelf life at 37 F was provided to eviscerated poultry by chilling two hours in ice water containing 10 ppm of chlortetracycline. Ziegler and Stadelman reported an extension of shelf life at 36 F of about five days by a 10 min dip in solutions containing 10 to 40 ppm chlortetracycline. Ayres *et al* in tests on ten antibiotics, reported an extension of about 5 days shelf life at 40 F for chlortetracycline, and comparable effectiveness for chlortetracycline and oxytetracycline at a concentration of 30 ppm. Control birds developed a bacterial population predominantly of the *Pseudomonas*, *Achromobacter* type, while the chlortetracycline treated samples developed significant proportions of yeasts. Yeasts were inhibited by two antifungal antibiotics that had little effect on the other flora present; hence a combination of antibiotics was recommended. In an evaluation of 15 min dips in water containing 10 ppm of chlortetracycline, Shannon and Stadelman found that shelf life extension by antibiotic increased as the storage temperature was decreased, ranging from an additional day at 68 F to at least 10 days extension at 32 F. Baker reported as high bacterial counts in controls after eight days as chlortetracycline treated samples had after 19 days, at storage temperatures of 32 to 35 F. Vaughn *et al* obtained increases in storage life at 45 F of zero to three days by antibiotic treatment in commercial type trials. Whole birds kept much better than those that had been cut up. In addition to all of the preceding antibiotic tests, which refer to chickens, Kraft *et al* (1958) have demonstrated an extension of the shelf life of chilled turkeys by use of antibiotics. From the above results, it may be stated tentatively that antibiotics have a definite but limited value in the handling of chilled poultry, and that they are certainly no substitute for good sanitation and low temperatures (near 32 F) in processing, transporation and retailing.

Since shelf life is limited to a considerable degree by bacterial growth (slime formation) on the skin layer, it is reasonable to assume that drastic changes in the skin surface, such as the removal of the epidermal layer by high temperature scalding, might have an appreciable effect on shelf life. Ziegler and Stadelman studied the effect of scalding temperature on shelf life of chilled poultry and found that approximately one day more shelf life was obtained with 128 F scald than with 140 F scald.

There is need for a rapid, reliable method for determining the numbers of bacteria on poultry, since most standard bacteriological counting techniques are tedious and time-consuming. The resazurin dye reduction test, which correlates well with bacterial contamination, has been suggested by Walker *et al* (1959) and by Wells (1959) as a possible rapid routine test in processing and distribution channels.

PART II: MILK PROCESSING

The function of the milk plant is the blending, processing, packaging and distribution of fluid cows' milk and milk products for safe human consumption. Most dairy plants will receive milk from several dairy farms and, unless specializing in milk from one breed of dairy cattle, from various breeds of cattle. This milk is usually mixed, then processed by separation and blended to produce a milk which will contain a uniform quantity of butter fat as required for the various items being distributed. Pasteurization is an important step in the processing as a means of destroying undesirable bacteria and for prolonging the keeping quality of the milk. Proper pasteurization will kill all pathogenic types of bacteria and nearly all other objectionable organisms but other heat resistant types of bacteria will continue to multiply unless the milk is cooled promptly after the pasteurization process. The bacteria contained in milk will multiply quite rapidly if it is held for any length of time at temperatures above 50 F. For prolonged keeping time milk should be cooled as promptly as possible after being taken from the cow to a temperature of 40 F or below and held at this temperature until it is consumed. Although milk is one of our most perishable foods, with proper refrigeration and processing, it will retain its acceptable flavor for 15 days or longer after it has been taken from the cow.

HANDLING MILK AT THE DAIRY FARM

Milk is collected at the dairy farm in either milk cans or farm bulk milk tanks. If cans are used the milk is usually cooled over a refrigerated Baudelot type cooler as the milk is dumped from the milker pails and before going into the cans. The night milking is usually held in a refrigerated room until the morning milking has been cooled and then both milkings are transported to either a receiving station or direct to the milk plant. If a farm bulk tank is used the milk is dumped directly into the tank from the milker pails or from the sanitary pipe of a milking system. The farm milk tank is insulated on sides and bottom and arranged with refrigerating surface built into the stainless steel lining of the tank. A motor driven agitator stirs the milk while it is being cooled. The motor is connected with the condensing unit so both will stop when the milk has reached the desired temperature as set on the thermostat.

Smaller farm milk tanks may have the condensing unit built into one end to form a package unit but larger tanks are arranged for remote location of the condensing unit. The condensing unit for the milk tank is sized so that all the milk from one milking will be cooled to 50 F within one hour after the milking has been completed. The second and other consecutive milkings are dumped directly into the tank with the milk already cooled. Milk from a bulk tank may be picked up at any time, day or night, depending on the requirements of the milk plant and in some areas, or on smaller farms, may be picked up every other day.

Milk from a bulk tank on the farm is picked up by an insulated stainless steel milk tank truck and transported either directly to the milk plant or to a receiving station where it is transferred to a larger tank truck. Properly insulated milk tank trucks do not require refrigeration because the raise in

Table 1 .... Requirements for Percent Butterfat in Dairy Products

Product	Butterfat
Skim milk	Not usually specified
Standard milk	3.0 to 3.8%
Special milk	4.0 to 5.0% (as labeled)
Half and half	10.0% (average)
Light cream (coffee)	16.0 to 20.0%
Heavy cream (whipping)	30.0 to 38.0%

temperature of the milk in transporation will only be one or two degrees.

If milk cans are used in transporting milk from the dairy farm to a milk receiving station some refrigeration may be necessary at the station to precool the milk before it is relayed to the milk plant. The refrigerating equipment at the receiving station will be sized depending on the amount of cooling to be done and the size of the can washer being used. The milk will be cooled as fast as it can be received and is usually passed over a surface type cooler or a plate type heat exchanger and discharged directly into a tank truck for transportation to the milk plant. If cans are used in transporting milk to the milk plant from the dairy farm it may be necessary to precool the milk at the plant unless closed trucks are used. Some dairy plants will receive milk both in cans and from tank trucks. Many milk plants are now providing precooling equipment to cool incoming milk, from either cans or tank truck, to a temperature as low as 36 F before passing the milk to the holding or storage tanks. This refrigerating load may fluctuate greatly and careful consideration should be given to the equipment selected.

HOLDING TANKS

Milk is usually received at the dairy plant faster than it can be processed making it necessary to have insulated tanks to receive the milk and hold it until it can be pasteurized. Some plants operate only five days per week and require tank capacity for holding milk received for two days. Tanks are usually 2000 to 5000 gal in size but some specially built tanks are in use up to a 8000 gal capacity. These tanks have stainless steel linings insulated with two or three inch thick jacketed insulation and have some type of agitation to keep the butterfat uniformly mixed in the milk. If milk is received cold enough or if it is precooled before going to the tanks it may not be necessary to provide refrigeration for the milk in storage. If some cooling is desired in the holding tanks they can be obtained with refrigerating surface built around the lining of the tank. This refrigerating surface may be an annular space formed by a plate welded to the outside of the lining suitable for direct expansion refrigeration or circulation of chilled water, or the surface may be arranged so chilled water will flow from a distributing pipe at the top and drain from the bottom of the lining. The refrigerating surface built into a holding tank is usually designed for cooling the milk at a rate of one degree per hour but tanks having surface for a faster rate of cooling can be obtained. An evaporator temperature of 28 F is the minimum that can be used for direct expansion cooling of milk to about 40 F without danger of freezing milk on the lining of the tank.

Milk will be continuously agitated while it is in a holding tank either by a slow speed propeller driven by a gear head motor or by filtered compressed air discharged into the tank by a perforated removable sanitary pipe extending along the bottom of the tank. Compressed air is usually supplied by a non-lubricated type compressor at a pressure slightly higher than the static head of milk in the tank.

Without refrigeration, a tank holding 40 F milk in a 95 F room will warm up approximately three degrees in 24 hr when tank has 2-in. thick insulation and will warm up about two degrees with 3-in. insulation.

STANDARDIZING

Before going through the pasteurizing process, the milk is standardized or blended to produce a product containing the amount of butterfat desired for the item being processed. All states and most larger cities have laws which establish legal minimum standards, usually on a basis of percent butterfat content, and in many states the percent of solids-not-fat is also specified. Table 1 shows the range in percent butterfat as required for dairy products in various states.

The greater portion of milk being processed in a plant will be put out as standard milk which will require a lower percent butterfat than contained in the milk as received from the dairy farm. The standard desired is obtained by either separating a part of the milk to skim milk and cream, using the skim milk to reduce the overall butterfat content in the milk or by removing the excess butterfat from the milk as it is being passed to the pasteurizing process. Most milk separators now being used are the closed type requiring a pump to force the milk through the separator with the skim milk being discharged through one sanitary pipe to a skim milk tank and another pipe discharging cream to the cream vat. Hot milk separators are available in capacities up to 20,000 lb of milk per hr and are designed for most efficient operation at milk temperatures of 90 to 100 F. Hot milk separation requires a means of heating the milk to the separating temperature. Equipment for cooling should be provided for both the cream and the skim milk as it leaves the separator before going to tanks or vats.

Cold milk separators are used in many plants as a means of eliminating the heating and cooling processes required for the hot milk machines. Milk is separated at 40 F at a rate of 5500 lb per hr input for the largest machine. Pumps required to supply milk to the separator are operated at a slower speed to prevent churning of the butterfat.

The newest type separator used in milk plants is known as a standardizing clarifier. This machine will handle milk at temperatures of 40 F or higher and is designed to remove from 0.1 to 2.0 percent butterfat from the milk being passed through it. This unit can be arranged to take milk from the holding tanks, as it was received from the dairy farm at about 4.5 percent butterfat, and deliver milk to the pasteurizing equipment at the standard desired for standard milk, for example, 3.5 percent. The surplus butterfat will be discharged as cream which can be used for blending to produce higher percent butterfat products. As a clarifier this unit separates out and holds in the bowl, sediment and animal tissue which otherwise should be removed from the milk by means of filters or strainers.

In standardizing the various items being distributed by a dairy plant there will often be a surplus of skim milk or cream or both. To utilize this surplus many plants have added equipment to process buttermilk, cottage cheese, and butter.

BATCH PASTEURIZATION

Batch or holder type pasteurization is accomplished by filling a vat almost full with raw milk, holding it to a temperature of not less than 143 F and holding the milk at that temperature or above for 30 minutes. After 30 minutes the milk may be drawn from the vat and then cooled before it is passed