EFFICIENCY OF "IMMERSION" REFRIGERATION OF CREAM

Refrigeration is being increasingly employed on Queensland dairy farms for the cooling and holding of milk and cream. At present between 25 and 30 per cent. of about 17,000 dairy farms have refrigeration available.

Over the 10-15 years that have elapsed since farm refrigeration units became both available and acceptable to a degree worthy of attention, two main types have evolved: the so-called "immersion" unit and the "air-cooled" type. In the former the cans of milk or cream are immersed to shoulder height in water chilled to around 34°F, with or without coolant agitation. Shock-cooling on a surface cooler is employed in the latter, using a sweet brine from a tank within the refrigerator cabinet, followed by storage in another cool air section. A small pump is necessary to circulate the coolant to and from the external shock-cooler when in use.

Theory

Despite conflicting opinions, some adverse criticism and certain undoubted disadvantages, the efficiency of the immersion system can be demonstrated.

Consider a can of milk or cream at 80°F standing in still air or unagitated water at 40°F. If the surface area of the can available for cooling be A sq. ft., the rate of cooling at the outset is given by $Q=K\ A(80-40)$ B.T.U. per hour, where K is the overall conductivity coefficient. The value of K is the critical factor, involving as it does an actual conduction of heat from the milk or cream to the cold water or air surrounding the can. Three separate passages are necessary to complete the heat transfer: firstly, through a stationary, closely adhering film of milk or cream on the inner can surface; secondly, through the metal thickness of the can; and finally, through the water or air film adhering closely to the outer surface of the can. In both cooling arrangements no difference occurs until heat transference through the outer film is considered. Where immersion refrigeration is employed the final heat passage is by conduction through a liquid film, whereas with air-cooling, conduction through a gas film is involved. The insulating effect of the latter, relatively speaking, accounts for the great difference in the cooling rates, it being, in fact, sufficient to make air-cooling quite inimical to preserving initial milk or cream quality. The inadequacy of air-cooling has been demonstrated by many workers and was indicated by the present author in studies on the efficiency of charcoal coolers (Few 1945).

Practical

Recently, small compressor units have been employed to provide cooling for water contained in farm-built insulated concrete tanks, such installations being designed primarily for cream cooling by can immersion on small-capacity farms.

The outlay involved varies from £70 to £100 in all, making the proposition particularly attractive. No shock-cooling equipment is included in the prices stated and the additional cost involved would amount to from 30 to almost 50 per cent. One advantage claimed for immersion cooling is that shock-cooling could be eliminated, thereby lowering the cost of the required farm installation and eliminating refrigeration losses unavoidably associated with the circulation of coolant around an external circuit.

An investigation was made in the 1961-62 summer over a period of two months to ascertain the necessity for combining shock-cooling with immersion refrigeration.

The farm chosen had been recently equipped with a farm-built insulated concrete cabinet of 6-can size. Two superseded domestic condensing units were reconditioned and used to provide refrigeration, operating from one thermostat. Together they were capable of cooling approximately 4 gal of cream per hr through a 50°F range. (Each gallon of cream requires the extraction of 500 B.T.U., and the rating of each cooling unit was 1000–1200 B.T.U. per hour). Overall cost of the farm installation was approximately £100, the shock-cooling equipment being an additional £30.

Over a period of eight weeks cream was alternatively immersion cooled or shock-cooled, using a surface cooler with water pumped from the cabinet, and then immersion stored. A small ½ in. centrifugal pump with separate motor drive circulated the chilled water. Experimental cans of cream were marked to be readily discernible at the factory but the grader was unaware as to whether or not shock-cooling had been practised. Particular attention was, however, given to the grading of all cream from this farm during the period of the trial. Delivery time was considerable, the farm being over 30 miles from the factory. During the period of two months the water in the cabinet was not stirred, the only mixing being that resulting from water pumping as required for shock-cooling. Cream was only stirred before leaving the farm and freshly produced cream was not at any time mixed with cream already under storage in the refrigerator tank.

Results

The results, which are summarized in Table 1, suggest that shock-cooling is definitely advantageous, although it must be pointed out that agitation of the tank water, as usually practised with immersion refrigeration, was not used during the "no shock-cooling" weeks. Further work is envisaged with a view to obtaining more data as well as evaluating the possibility that provision of water agitation might avoid the necessity for shock-cooling. A relatively simple but inexpensive method of achieving this end is contemplated, the cost of which would be very much lower than that for the usual shock-cooling equipment. It is also considered that immersion cooling would be much more rapid for the small amounts of cream produced on farms for which the particular method of cooling under review was developed.

TABLE 1

CREAM GRADING DETAILS

Week Commencing	Shock-cooling	Grading and Weight (lb)
December 4	No	Choice 291 First 139
December 11	Yes	Choice 313 First 80
December 18	No	Choice 458 First 377
December 25	Yes	Choice 418 First 79
January 8	Yes	Choice 886 First 242
January 15	No	Choice 297 First 78
January 22	Yes	Choice 562 First 159
January 29	No	Choice 473 First 224
Totals	No	Choice 1,519 First 819
	Yes	Choice 2,179 First 560

REFERENCE

FEW, F. G. (1945).—The efficiency of charcoal coolers for holding cream on farms. *Qd J. Agric. Sci.* 2:190-7.

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