Rancid Flavor in Fresh Milk

activating effect of some pipeline milkers and farm tanks apparently major cause of rancidity

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The increased incidence of rancid-flavored milk in California in recent years is at least partially attributable to treatments milk receives in some pipeline milkers and farm tanks. However, careful selection, installation, and operation of this equipment can reduce difficulty with the off-flavor.

Dairy chemists believe that all milks contain an enzyme or group of enzymes known as lipase, which—under certain conditions—is able to partially hydrolyze fat, splitting off the fatty acids responsible for the rancid flavor. But normally the fat in milk is surrounded by a thin film of absorbed protein that appears to protect the fat from the lipase. If this protective film is disrupted or modified, the lipase is able to act on the fat, freeing fatty acids.

Conditions that modify the fat surface, permitting lipase action, are known as activation treatments. Two activation treatments that may be encountered during milk production are: *1*, agitation of warm milk, and *2*, temperature-fluctuation treatments—such as cooling milk, warming it to about 86° F, and then cooling it again.

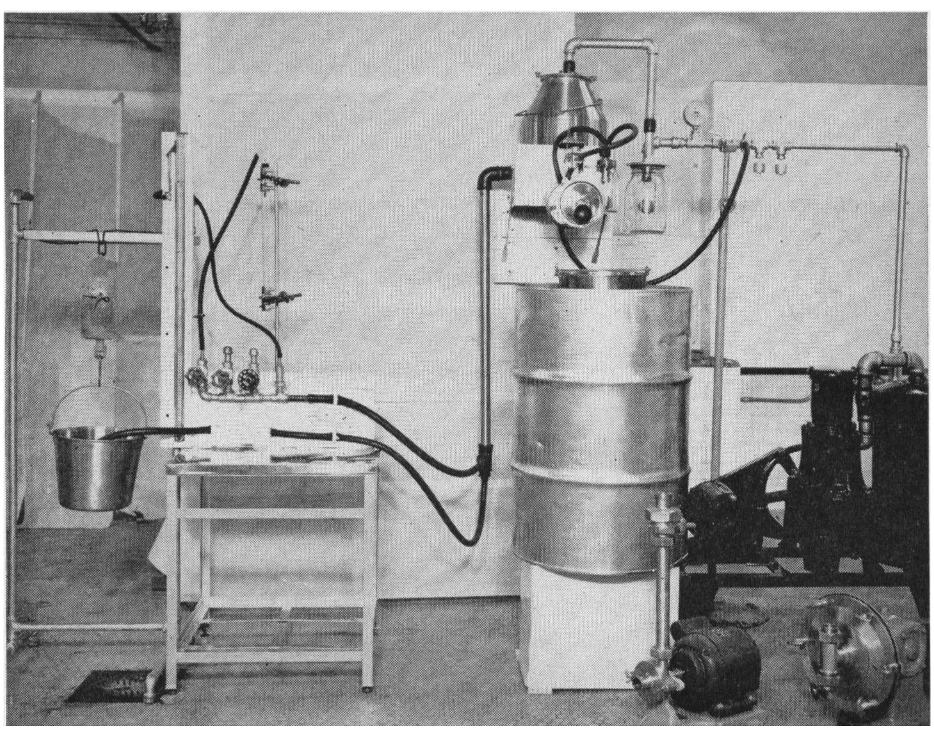
There is little opportunity for milk to receive such treatments when bucket-type milking machines, surface coolers, and 10-gallon cans are used—especially in combination with daily delivery and processing. Activation is much more likely with more modern equipment—such as pipeline milkers and cold-wall farm tanks—and with every-other-day pickup and processing.

Pipeline Milkers

During 1953, a research project was undertaken on the Davis campus of the University of California to study the factors in pipeline milkers influencing induced rancidity in milk.

Most of the experiments involved passing milk several times through individual parts of a pipeline milker. Samples taken after each pass were held under refrigeration for one day—to permit development of the off-flavor—and then examined for intensity of rancidity. The extent to which the equipment or condition under study contributed to activation was measured by the number of passes needed to induce rancidity, in conjunction with the intensity of the defect.

Part of the equipment used to study the activating effect of individual parts of a pipeline milker. Milk was drawn from the pail suspended from the scale at a controlled flow-rate. Simultaneously measured air was introduced with the milk at the "T" into the riser or other equipment being tested. In most cases, the milk was removed from vacuum by the releaser and discharged into the receiving pail suspended in a water bath used to maintain a constant temperature.



Varied Operating Conditions

One of the most activating parts of a pipeline milker proved to be a riser—a section of pipe in which milk is lifted under vacuum with air bubbling through it. The activating effect appeared when air was introduced along with the milk and increased as the amount of air increased. A riser did not induce rancidity if no air was admitted.

Air appears to increase the activating effect in certain sections of a pipeline milker by causing more violent agitation. In addition, the increase in milk surface exposed to air probably favors changes in the surface of the fat globules.

Practical Difficulties

The obvious approach to preventing the activating effect of air is to eliminate air from the pipeline as completely as possible, but such control is limited by practical difficulties. Manufacturers of pipeline milkers have found it necessary to admit some air at the milking unit in order to maintain a relatively uniform vacuum in the equipment and to promote rapid removal of milk. Even if air were not admitted intentionally, it would be difficult to keep it out of the milk line. Variable amounts of air leak past the teat cup during milking, depending—at least partially—on the shape of the cow's teats and the stage of milking. In addition, there is variation among operators in the amount of air admitted during machine stripping and in changing units from one cow to another. Even the gas

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MILK

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that comes out of solution—as milk is exposed to vacuum—contributes to the total amount of air contained in the milk line.

Normal variations in vacuum level are apparently not an important factor influencing activation. Experimental comparisons of 12″, 15″, and 18″ of vacuum did not show any differences.

Milk flow-rate had a marked influence on the activating effect of air. Higher flow-rates decreased the time of agitation in the riser, thereby reducing activation. By increasing the flow-rate, a greater number of passes was required to induce rancidity, and the intensity was decreased. It follows that difficulty with rancidity will be reduced by two practices—selection of heavy producers and rapid milking—that are important for efficient milk production.

The temperature of milk during agitation influences both activation and churning. Cooling milk from body temperature reduces the activating effect of agitation. Churning, on the other hand, increases as temperature is decreased to 85° F, and then falls off again with lower temperatures. Therefore, cooling milk in the pipeline would probably reduce activation but increase churning, unless the temperature could be reduced appreciably below 85° F—70° F maximum—before the milk is subjected to serious agitation. The difficulties involved in cooling milk to that extent before it passes through any equipment that causes activation make such a solution seem impractical at present.

Units Tested

Attempts were made to modify the riser to reduce activation of milk passing through it at fixed air and milk flow-rates.

The activating effect of vertical risers was approximately proportional to the height they lifted the milk. Use of sloped pipes instead of vertical risers to lift milk a given height did not decrease the activation. Use of several short risers was worse than one longer one, probably because of increased opportunity for agitation at the extra elbows.

No advantage was gained by using pipe sizes different from the 1½″ diameter commonly used. At milk and air flow-rates comparable with their capacities, the milk hose tested in lifting milk from the teat cup to the pipeline caused activation similar to that of the vertical sections of the 1½″-pipe of the same height.

No trouble with induced rancidity was encountered in straight pipeline sections mounted either horizontally or with a slight downward slope, but slight activation occurred in pipe sloped upward as little as .10″ per foot. Fittings such as elbows and T's induced more rancidity than straight sections of pipe of the same length.

Either a bag- or plate-type filter installed in vertical sections of the vacuum line caused more activation than a riser alone. No induced rancidity developed when either filter was placed in a vertical discharge line from a pump.

The method of removing milk from vacuum may have a marked influence on the amount of activation it receives. No rancidity of practical significance was induced by a diaphragm pump or by a 3,500 rpm centrifugal pump, when it was operated intermittently in accordance with the supplier's recommendations. But rancidity was induced rapidly by continuous operation of a centrifugal pump at a flow-rate below its capacity. Activation was markedly reduced by throttling the pump on the discharge side to keep it flooded, but not as much as by intermittent operation. The releaser alone did not induce rancidity but, in practice, releasers are frequently used in conjunction with risers, which combination is inferior to a properly operated pump.

Farm Tanks

Rancidity induced by treatments that milk receives in farm tanks has been encountered on a number of ranches. Either agitation or temperature activation, or both, may be involved. Where slow cooling is encountered in a cold-wall tank, the milk may be subjected to prolonged agitation at activating temperatures before it is cooled enough to prevent activation.

Cold-wall tanks may also create opportunities for temperature activation—in several ways: If warm milk is added directly to cold, part of the cooled milk may be rewarmed by contact with the incoming milk, and then cooled again. This is particularly probable when the milk level is below the bottom of the agitator. If side-wall cooling is used, when the tank is almost full, the cooling surface may be submerged to the extent that warm milk has no opportunity to be cooled before mixing with the cold milk. When refrigeration is inadequate, milk cooled after one milking may be rewarmed to some extent by the addition of milk during a later milking.

Milk that will not go rancid when subjected to mild activation by either agitation or temperature fluctuation alone will frequently develop objectionable rancidity when it is subjected to both treatments.

When milk is cooled over a surface cooler and then stored in an insulated farm tank, there is very little opportunity for either agitation or temperature activation.

In a number of cases where rancidity was at least partially induced by treatments milk received in a cold-wall tank, the difficulty was prevented or reduced by increasing the capacity of the compressor used with the tank. Rapid cooling would be expected to reduce both temperature and agitation activation. The design of the heat transfer surface, its area, and agitation of the milk are important factors influencing rate of cooling. These factors, not the compressor size, may limit rate of cooling in some tanks.

The agitator used in a farm tank may have a marked influence on the development of induced rancidity. Proper design depends on tank shape and operating conditions. Increasing the agitation in some tanks may reduce rancidity by increasing the rate of heat transfer, thereby decreasing the opportunity for temperature activation. Decreasing the agitator speed or size of the blades may reduce agitation activation in other tanks. On the basis of limited experimental results, it appears that air agitation tends to induce rancidity more than does mechanical agitation.

Susceptibility

The susceptibility of milk to induced rancidity is an important factor in determining whether a particular treatment will result in development of rancidity. In most cases, rancidity is encountered only during short periods when the milk is most susceptible. The susceptibility of the milk should be reduced as much as possible by such measures as the use of green succulent feeds, when available, and the elimination of cows producing the most susceptible milk, particularly those in advanced lactation.

When rancidity is encountered in raw milk, samples should be taken from the discharge of the pipeline milker and from the farm tank to determine the extent to which they may be inducing the flavor, and—if necessary—appropriate corrective measures applied. Samples taken from individual cows should help establish the incidence of spontaneous rancidity and guide elimination of those cows which produce the most susceptible milk.

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