

EFFECT OF PIPELINE MILKING AND BULK HANDLING ON THE ACID DEGREE OF RAW MILK¹

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Composite samples of milk taken at several stages in the milk-pipeline and bulk handling system were tested for acid degree. It was apparent that a large part of the rancidity induced by the system studied had its origin in the plastic milk hose between the milking unit and the pipeline. This influence was compounded when a milk-metering device was placed in the line, possibly as a result of the additional length of milk hose required by its installation. The data further show that handling after the pipeline operation has no influence in the development of the rancid flavor beyond that already initiated in the pipeline itself or spontaneously present in the milk.

With the increased use of pipeline milkers and bulk handling of milk during the past few years, the problem of rancidity in milk has been growing in importance. The general problems of rancidity, lipolysis, and lipase action in milk have been reviewed by Herrington (4, 5) and are generally understood by workers in the dairy industry. When milk is drawn from the udder and held warm, the lipase remains relatively inactive (3, 9); but agitation of the warm milk rapidly increases lipase activity. On the other hand, lipase activity is accelerated in cooled milk; although agitation of cooled milk produces less change in the activity (2). Other workers (1, 7, 8, 11) report that rancidity is initiated by foaming, turbulence, and agitation while milk is warm and the fat is in a liquid state. More complete studies (6, 10) of hydrolytic rancidity in pipeline milkers and bulk tanks show that acid degree is increased by the number and height of risers, length of line, excessive air intake causing foaming, continuous operation of starved milk pumps, and lack of full lines. With few exceptions, bulk cooling tanks and transport tanks can be eliminated as being the cause of hydrolytic rancidity in milk.

This study was undertaken to determine where changes in acid degree might occur in the handling of raw milk through a conventional pipeline and bulk handling system.

EXPERIMENTAL PROCEDURE

Samples of raw milk were collected at the University Dairy Farm and the University Plant. These samples were analyzed for acid-degree values (ADV) using the Simplified Method for Hydrolytic Rancidity in milk developed by Thomas *et al.* (12). This meth-

od expresses the rancidity in terms of acid-degree value (ADV) where milk with a value of 1.3 is considered as turning rancid and a value of 2.3 as definitely rancid. Herrington and Krukovsky (3) report that several procedures are in use for measuring acid-degree values; all yield essentially the same results, though there are small differences.

Samples for analysis were collected at the various stages throughout the milk-handling procedure as follows:

1. Composite sample of milk from all cows before milking machine was attached.
2. Composite sample taken after milk had passed through milk-metering device.
3. Composite sample taken after milk had passed through the pipeline system and before it entered the cooling tank (end of pipeline).
4. Sample of milk from the cooling tank, after cooling and storage for 10 hours (morning milk only).
5. Sample from transport tank after night storage and before hauling to dairy plant (morning and evening milk).
6. Sample from tank after transportation to the plant and before milk was pumped into pasteurizing vat.
7. Sample from pasteurizing vat before heating.
8. Sample of pasteurized milk.

Samples were taken for a period of 18 months. During the first 10 months of the experiment, the samples were taken once a month and analyzed for ADV within one to two hours after sampling. For the last eight months, samples were taken twice a month and held for 12-16 hours at 38°F. before analysis. A 1½-in. glass line carried milk to the receiving jar from inlet valves located 30 ft. to 48 ft. distant in the milking parlor. There were two 90° and two 45° elbows, but no risers in the line. A continuously operated diaphragm pump was used. An 8-ft. plastic milk hose carried milk from the teat-cup assembly to the pipeline located 6 ft. above the cowstall floor. When the milk-metering device was used, an extra 5 ft. of milk hose was used, making a total of 13 ft. of milk hose from cow to pipeline. The milk was cooled to within 38° to 40°F in an ice-bank-type cooling tank within an hour after milking was completed.

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TABLE 1. AVERAGE ACID DEGREE VALUES OF MILK SAMPLES TAKEN AT VARIOUS STAGES OF THE BULK HANDLING SYSTEM

Description	No. Trials	Composite (Cow)	Metering device	End of pipeline	Bulk tank prior to P.M. Milking	Transport Farm	tank Plant	Past. Vat	Past. Milk
Part I ^a									
Pipeline only	7	0.54±.05 ^b	- -	0.84±.18	1.13±.16	1.08±.15	1.14±.15	1.15±.16	1.20±.14
Milk metering device + pipeline	3	0.47±.09	0.68±.04	0.84±.15	N. S.	1.61±.49	1.73±.55	1.69±.53	1.89±.46
Part II ^c									
Milk carried to bulk tank	5	0.55±.08	- -	- -	0.60±.11	0.65±.08	0.64±.11	0.66±.10	0.79±.10
Pipeline only	5	0.55±.09	- -	0.86±.18	1.02±.23	1.00±.22	1.00±.18	1.02±.19	1.03±.22
Milk metering device + pipeline	9	0.56±.03	0.99±.16	1.16±.20	1.51±.33	1.63±.46	1.63±.40	1.64±.41	1.71±.44

^aSamples analyzed after collection

^bValues after ± signs indicated standard deviation

^cSamples held 12-16 hr. prior to analysis

RESULTS AND DISCUSSION

Average acid-degree values of milk samples taken at various stages of the bulk-handling system are presented in Table 1.

During the first phase of the experiment, duplicate composite samples were taken both morning and night from cows, from the milk-metering device, and from the end of pipeline. One sample of each was cooled immediately to 38°F, while the other was not cooled and remained at room temperature until analyzed, one to two hours after sampling. When the acid-degree values were tested statistically by the analysis of variance, there was no significant difference between morning and evening milk or between warm and cooled samples at each of the above points of sampling. Therefore, values for all four samples were used in computing the average values in Part I of Table 1.

The increase in ADV between the cow and the pasteurized product was considerably greater when

the milk passed through the pipeline than when it was hand-carried to the bulk tank. This increase was magnified when a milk-metering device was placed in the line. Examination of the ADV of samples taken at various stages in the handling process reveals that these differences can be traced directly to the agitation of milk occurring in the hose between the milking machine and the pipeline. The added effect of the presence of the milk-metering device is believed to be a result of the additional five-foot length of hose it introduces into the system, rather than the mechanics of the device itself. By observation through plastic hoses, there appeared to be more agitation, churning action, and foaming in the hose from the outlet hose of the milk-metering device to the pipeline than in the hose from the cow to the pipeline or metering device. Irvin (8) states that air agitation tends to induce rancidity more than does mechanical agitation. Only a slight increase in ADV could be traced to agitation of the milk in the bulk tank or tank truck or during plant handling.

Table 2. AVERAGE INCREASE IN ACID DEGREE VALUE BETWEEN SAMPLING POINTS^a

	Cow - metering device	Cow - end of pipeline	Cow - bulk tank	Cow - past. milk	End of pipeline - bulk tank	Bulk tank - past. milk
Milk carried	- -	- -	0.05	0.24	- -	0.19
Pipeline only	- -	0.31	0.47	0.48	0.16	0.01
Milk metering device + pipeline	0.43	0.60	0.95	1.15	0.35	0.20

^aData from Part II of Table 1 used

Table 2 shows the average increase in ADV between sampling points and, for the most part, is self-explanatory. The data show that, when milk is cooled rapidly and held at a low temperature, near 38 F, the increase in ADV is directly related to the amount of agitation. Holding the cooled milk an additional 12 to 16 hours (bulk tank to pasteurized milk) did not appreciably increase the ADV. These differences, when tested statistically, using the *t* test, were found to be non-significant.

Results indicate that induced rancidity of milk could be reduced by installing pipeline systems at a lower level and thereby eliminating long milk hoses. The data also agree with a previous report (8) that, with few exceptions, agitation of cold milk in bulk cooling and transport tanks can be eliminated as being the cause of hydrolytic rancidity in milk.

Variations in the degree of rancidity due to season and stage of lactation are not considered in this study. However, data obtained in a limited number of trials suggest that milk from cows in late stages of lactation is more susceptible to induced rancidity than milk from cows in the early months of lactation. Such a possibility is worthy of further study.

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