A Study of Factors Involved in the Development of Rancid Flavor in Milk

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The Story in Brief

Even though the rancid flavor problem was practically unknown to dairy farmers before the introduction of bulk tank systems, this great advancement should not be blamed as the cause. In many instances, the problem is due to improper procedures in the operation of bulk tank systems and/or practices which have come about as a result of bulk tank systems.

With bulk tank systems, it is possible to cool milk much more rapidly than it was by the general cooling methods used in can operations. It is also much easier to maintain lower milk storage temperatures with bulk tank systems. These improved cooling and storage facilities led to widespread adoption of every-other-day pickup of milk as an economy measure. As has been shown in this study, these three factors contribute very materially to the development of rancid flavor in milk.

The addition of milk pipeline systems has also aggravated the rancid flavor problem, but this was largely due to improper installations or malpractices. The proper installation of milk lines, the intermittent operation of milk pumps and prevention of air leaks would do much to insure the successful operation of pipeline systems. Low producing cows are less likely to be detected when the usual type of pipeline system is used than they are when pail milking is used, but careful observation on the part of the dairy farmer would do much to eliminate the rancidity contributed by low producing cows.

When all the causes of rancid flavor associated with bulk tanks and milk pipelines have been eliminated, and the problem still exists, the dairy farmer must look elsewhere for a solution to his problem. Cows that are producing a small quantity of milk and are late in their lactation period should be the first consideration. If silage is being fed, the amount may have to be reduced or it may have to be eliminated entirely. If the elimination of all of these causes fails to solve the rancid flavor problem, the only other alternative would be daily marketing of the milk. In some situations it may be possible for the dairy farmer to have the tank truck stop for daily pickup. In other situations the dairy farmer may have to arrange for special hauling. This would be more profitable than holding the milk for two days and then having it rejected.

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The introduction of bulk milk tanks on Oklahoma dairy farms was accompanied by an increase in the "rancid flavor problem" in the state's milk-processing plants. The problem appeared to be especially acute in the milk coming from certain individual farms. Therefore, an investigation of the relationship of rancid flavor to the way milk was handled between the cow and the milk plant was started in the latter part of 1955. This study was superimposed on an existing study of the tendency for rancid flavor to appear in the milk from individual cows. As these studies progressed, related factors such as season of year and atmospheric temperature came to be involved.

Related Previous Studies

Several workers (*6, 8, 11*) * have observed that the rancid flavor problem is highly seasonal, reaching its peak during the winter, with little or no difficulty being experienced during the summer.

Many workers (*1, 2, 3, 6, 8, 11*) have observed that individual cows vary in the tendency to produce milk which develops a rancid flavor. Some of these workers also observed that this tendency varied considerably from day to day in the same cow. In two studies (*2, 8*) it was observed that the tendency was greatest during the later stages of lactation.

Mechanical factors reported as being related to development of rancid flavor in milk include agitation due to milk-line pumps, air bubbles through vertical sections in the milk line, and air leakage into the milk line (*7, 8, 9*). In some of these studies it was observed that those types of agitation most conducive to foaming were those most often associated with rancidity.

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*Numbers refer to Literature Cited, page 27.

The research reported herein was done under Oklahoma Station Project 931.

Method of Determining "Rancid Flavor"

In the studies reported herein, the method used to determine the degree of rancid flavor in milk was that designed by Thomas *et al. (10)*. The amount of free fatty acid producing the flavor is expressed as "fat acid degree," and generally abbreviated to "FAD." An FAD value of approximately 2.00 or greater is considered to indicate a definite rancid flavor.

Except where otherwise stated, samples were held for 48 hours at 35° F. before the rancid determination was made in the laboratory.

Experimental Procedures

The group of related studies reported herein extended over a period of more than four years, from January of 1956 through June, 1960. They developed through a series of eight fairly distinct phases:

I. A survey of dairy farms using bulk tanks in the Oklahoma City milkshed. (January, 1956)

II. A series of exploratory studies of the effect of agitation in a vacuum tank, agitation in the pipeline, and delayed as compared to immediate cooling of the milk. (April 1956 into December 1957)

III. An experiment designed to determine the effect of exposing milk to a vacuum during cooling. (March 1957)

IV. Monthly determinations of the FAD values of milk produced by each individual animal in the University milking herd of approximately 130 cows. Each sample was split, with half being cooled immediately and the other half remaining at atmospheric temperature until sampling was completed. Data were analyzed by season of year, and by stage of lactation, level of production, and lypolitic activity of the milk of individual cows. (December 1957 into January 1959)

V. Comparison of immediate and delayed cooling on 19 dairy farms in the Stillwater milkshed and at the Station's experiment barn. (February and March, 1959)

VI. Comparison of four holding temperatures (32, 37, 42 and 47 degrees F.), and two holding times (24 and 48 hours), for each of 62 individual cows. (December 1959 and January 1960)

VII. Daily variation in samples from 12 individual cows when milk was stored at two different temperatures, and relation of development of rancid flavor to the cow's level of production and the atmospheric temperature. (February through June, 1960)

VIII. Relative FAD values for cows fed sorghum silage and those fed alfalfa hay. (April 1960)

Survey of Bulk Tanks in the Oklahoma City Milkshed

In January, 1956, a survey of bulk tanks in the Oklahoma City milkshed was made in cooperation with the Central Oklahoma Milk Producers' Association. The Association's truck drivers took samples from each of the 243 bulk tanks where they collected milk. Two sets of samples were taken with a time lapse of one week between samplings. For each sample, the driver recorded the type of bulk tank, type of pipeline pump (if used), and the temperature of the milk at the time it was picked up. The samples were transported in the refrigerated compartment of the tank truck. The temperature was maintained at about 40° F. The FAD value of each sample was determined at the Station's dairy laboratory at Stillwater.

Information obtained through this survey is reported in Table I.

Table I.—FAD values of milk collected from bulk tanks, by type of milking system; Oklahoma City Milkshed, January, 1956.

	No. of Installations	Average FAD Value	Samples Having FAD Values Above 2.00	
			Number	Percent
PIPELINE SYSTEMS				
Vacuum types				
Tank	20	1.99	9	45.0
Releaser	23	1.57	5	21.7
Total or average	**43**	1.76	**14**	32.6
Pump types				
Diaphragm	15	1.81	4	26.7
Centrifugal	11	1.23	1	9.1
Total or average	**26**	1.70	**5**	19.2
All pipeline systems				
Total or average	**69**	**1.69**	**19**	**27.5**
NON-PIPELINE SYSTEMS	174	1.14	7	4.0

Exploratory Studies of Agitation and Cooling

The series of exploratory studies which started in April 1956 were conducted at the Station's experiment barn, using an 18-cow milking herd. The milking system included a vacuum tank and pipeline. A ten-gallon milk can with a vacuum head was inserted in the pipeline at the discharge end, just before it entered the tank. Thus, it was possible to secure samples at the weigh can, at the end of the pipeline, and from the tank.

Agitation in Pipeline and Vacuum Tank

Attention was given first to the effect of agitation occurring in the pipeline and vacuum tank.* Individual-cow samples were taken from the discharge end of the pipeline and set on a table at atmospheric temperature until all samples had been taken. Then a sample was taken from the tank. For the agitation study, the tank sample was compared with a composite of the individual cow samples, with each cow represented in the composite according to the number of pounds of milk she had produced. Nine sets of samples were taken at various dates between April 3 and June 22, 1956. The FAD values are shown in Table II.

*The effect of the mild agitation due to an agitator in the bulk tank was briefly studied at the University milking barn, where a vacuum tank and pipeline system was used. When the amount of agitation was decreased 50 percent by manual operation of the agitator switch, there was no change in FAD value.

Table II.—FAD values of composite samples taken at end of pipeline and of samples of same milk taken from vacuum tank.

Sampling Date	Fat Acid Degree	
	Tank End of Pipeline	Inside Tank
April 3, 1956	1.24	2.84
April 5, 1956	1.05	2.89
April 17, 1956	2.40	2.80
April 24, 1956	2.00	2.58
May 1, 1956	2.55	3.77
May 3, 1956	1.22	4.12
May 7, 1956	0.98	3.68
May 17, 1956	2.22	5.90
May 22, 1956	2.04	4.43
Average	**1.74**	**3.67**

Table III.—FAD values of samples taken at weigh can and of samples of same milk taken at discharge end of pipeline.

Sampling Date	Fat Acid Degree	
	Weigh Can	Tank End of Pipeline
May 17, 1956	1.22	2.22
May 22, 1956	1.22	2.04
May 31, 1956	1.89	3.00
June 26, 1956	1.29	1.78
June 27, 1956	1.78	1.87
June 28, 1956	1.47	1.80
June 29, 1956	1.29	1.94
Avg. for period	**1.45**	**2.09**
Jan. 12, 1957	1.11	1.33
Jan. 19, 1957	1.11	1.45
Avg. for period	**1.11**	**1.39**
March 7, 1957	1.11	1.67
March 20, 1957	1.45	1.45
April 4, 1957	1.11	1.45
May 16, 1957	1.11	1.78
Avg. for period	**1.20**	**1.59**
Nov. 1, 1957	1.11	1.66
Nov. 3, 1957	0.82	1.33
Nov. 19, 1957	1.04	1.00
Nov. 20, 1957	1.04	1.04
Avg. for period	**1.00**	**1.26**
Over-all average	**1.25**	**1.69**

To study the effect of agitation in the pipeline, individual cow samples were taken from the weigh can and also at the end of the pipeline. All samples remained at atmospheric temperature until sampling was completed. Seven sets of samples were taken in May and June of 1956, and two more sets were taken in January of 1957. After that, attention was switched to the effect of delayed vs. rapid cooling. However, weigh can samples were continued through two additional periods, so a total of 17 sets of samples eventually was available. Table III shows the FAD values obtained from this study.

Delayed Cooling

About February, 1957, it began to appear that immediate cooling might be related to the development of rancid flavor in milk. In the

Table IV.—FAD values of samples taken at discharge end of pipeline, when (a) cooling was delayed and (b) cooling was started immediately.

Sampling Date	Fat Acid Degree		
	Weigh Can*	Tank End of Pipeline	
		Cooling Delayed*	Cooled Immediately
March 7, 1957	1.11	1.67	2.22
March 20, 1957	1.45	1.45	1.78
April 4, 1957	1.11	1.45	1.67
May 16, 1957	1.11	1.78	3.33
Nov. 1, 1957	1.11	1.66	1.44
Nov. 3, 1957	0.82	1.33	1.44
Nov. 19, 1957	1.04	1.00	1.11
Nov. 20, 1957	1.04	1.04	1.33
Dec. 2, 1957	**	1.26	1.46
Dec. 3, 1957	**	1.11	1.22
Dec. 9, 1957	**	1.11	2.00
Dec. 10, 1957	**	1.10	1.66
Average	**1.10**	**1.33**	**1.72**

*Samples for the period March 7 through November 20, inclusive, are the same samples shown for those dates in Table III.

**Weigh can samples not taken.

tank agitation study, samples suddenly cooled in the tank had developed higher average FAD values than those which stood for a time at atmospheric temperature (Table II). Furthermore, in the pipeline agitation study up to that time, only one set of samples (that taken at the end of the pipeline on May 31) had developed an FAD value approaching the average of those taken from the tank (Table III). Therefore, the procedure was altered to permit a direct comparison between delayed and immediate cooling. The samples taken at the discharge end of the pipeline were split. Half was placed immediately in circulating ice water, where it cooled to 32° F. in about ten minutes. The other half was left at atmospheric temperature until milking was completed. The FAD values are shown in Table IV.

Exposure to Vacuum During Cooling

In studying the effect of exposure of milk to a partial vacuum during cooling, individual cow samples were split three ways. One portion, used as a control, was cooled immediately to 32° F. The others were placed in two closed containers cooled by a common water bath and agitated by two magnetic agitators operating at the same speed. One was subjected to a 20-inch vacuum; the other remained at atmospheric pressure. Two series of 35 ml. sub-samples were taken from each container at the end of 30 minutes after cooling started, and again at the end of an hour when cooling was assumed to be completed.

Results are shown in Table V. The higher temperature at the end of 30 minutes for the sample under vacuum is assumed to be due to a slower rate of cooling at reduced pressure.

Table V.—FAD values of milk cooled at atmospheric pressure and milk cooled under vacuum.

	Temperature* (deg. F.)	FAD Value
Control**		1.75
Atmospheric pressure		
After cooling 30 minutes	40	1.63
After cooling 60 minutes	33	1.32
Vacuum (20 inches mercury)		
After cooling 30 minutes	44	1.55
After cooling 60 minutes	33	1.18

*Initial temperature of all samples was 102° F.
**Cooled immediately to 32° F. at atmospheric pressure.

Studies at the University Dairy Barn

In December, the study was transferred to the University dairy barn, where about 130 cows were being milked. The sampling set-up was similar to that at the experiment barn; that is, samples could be secured at the weigh can, and at the discharge end of the pipeline. The only essential difference was that at the big barn a vacuum-releaser milking system was used, rather than the vacuum-tank system used at the experiment barn.

Samples were taken once each month from each cow being milked at the time the samples were taken. Samples were taken from the discharge end of the pipeline. As before, each sample was split, with half being cooled immediately in circulating ice water and the other half being left at atmospheric temperature until milking was completed. The delay in cooling was as much as one or two hours for samples taken at the beginning of the milking period. All samples were held at 34° F. for approximately 48 hours.

Monthly sampling was begun in December 1957 and continued through January 1959. The individual cow data for the calendar year 1958 were then analyzed in various ways.

Delayed vs. Immediate Cooling

When the individual cows were ranked in order from highest to lowest average FAD values for the month of February 1958, it was found that 17 had averages of 2.00 or more when the milk was cooled immediately.

Therefore, a comparison was made between these 17 and two other groups: (1) The 17 cows with the lowest average FAD values; and (2) the 17 standing nearest the herd average. The results are shown in Table VI. In all groups, the FAD values averaged lower when cooling was delayed. Also, immediate cooling had the most effect, percentage-wise, in the group of cows showing the highest average FAD values.

Table VI.—FAD values of milk of high, medium, and low lypolitic activity when (a) cooling was delayed, and (b) cooling was started immediately.

	Average FAD Values		Percent Increase When Cooled Immediately
	Cooled Immediately	Cooling Delayed	
Cows producing milk in which tendency to develop rancid flavor was*—			
High	2.70	1.65	63.5
Medium	1.43	1.05	36.2
Low	0.94	0.84	11.9

*Seventeen individual cow samples were used in each group.

Level of Production

In Figure 1 the average FAD values of the individual cow samples are shown in relation to the total pounds of milk produced by each cow on the day that the sample was taken. Daily production records were grouped according to the seven groups as indicated in Figure 1. The corresponding FAD values were then grouped and averages for each group determined. For a daily production of 10 pounds or less the average value was 1.70; this declined consistently as daily production increased.

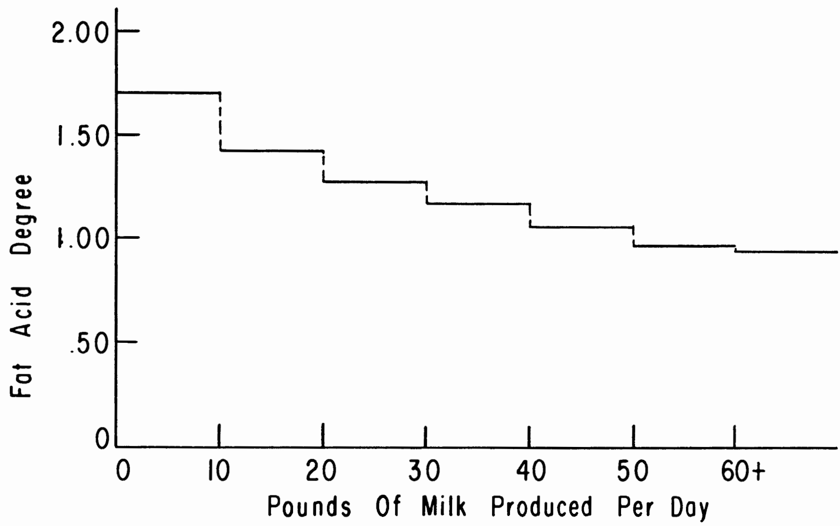

Figure 1. Influence of level of production on fat acid degree of milk.

Stage of Lactation

Table VII and Figure 2 show the relationship between month of lactation and the percentage of cows in each month which produced milk that developed a rancid flavor. Of the total number of cows in the study, there were 160 in their first month of lactation, ranging down to 65 in their tenth month (Table VII). The curve was extended to the eleventh month since there were 50 cows represented at that stage. There were also 37 cows in their twelfth month of lactation, at which time 29.73 percent produced milk that developed a rancid flavor. The normal curve ranged from .63 percent for the first month to 12.30 percent for the tenth month of lactation. Twenty percent of the cows in their eleventh month produced milk that went rancid.

Observations made during the course of this study indicate that stage of lactation appears to influence the incidence of rancid flavor to a high degree. Several farmers who were seeking a solution to their rancidity problem brought in samples from the individual cows in their herds. When exceptionally high FAD values (4.0 to 12.0) were obtained, a check-back always revealed that the sample was from a cow that was late in her lactation and producing a small quantity of milk.

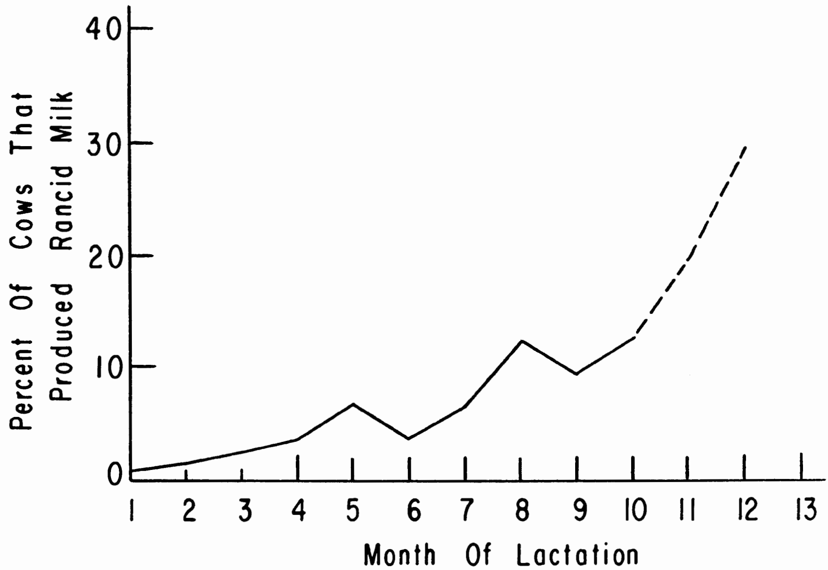

Figure 2. Relationship between stage of lactation and the incidence of rancid flavor in milk.

Table VII.—Relation of stage of lactation to incidence of rancid flavor in milk of individual cows.

Stage of Lactation (month)	No. of Cows at This Stage When Sampled	Cows Producing Milk with FAD of 2.00 or More	
		Number	Percent
1st	160	1	0.63
2nd	161	2	1.24
3rd	142	3	2.11
4th	131	5	3.51
5th	135	9	6.66
6th	119	4	3.36
7th	106	7	6.60
8th	98	12	12.24
9th	75	7	9.33
10th	65	8	12.31
11th	50	10	20.00
12th	37	11	29.73

Season of the Year

Figure 3 shows the results of plotting the data obtained from the University herd of approximately 130 cows against each month of the year. In January, sixteen percent of the cows in the herd produced milk that went rancid, while in July only one cow or less than one percent of the cows in the herd produced milk that went rancid. This agrees with milk plant experience that the rancid flavor problem is most acute in the winter months.

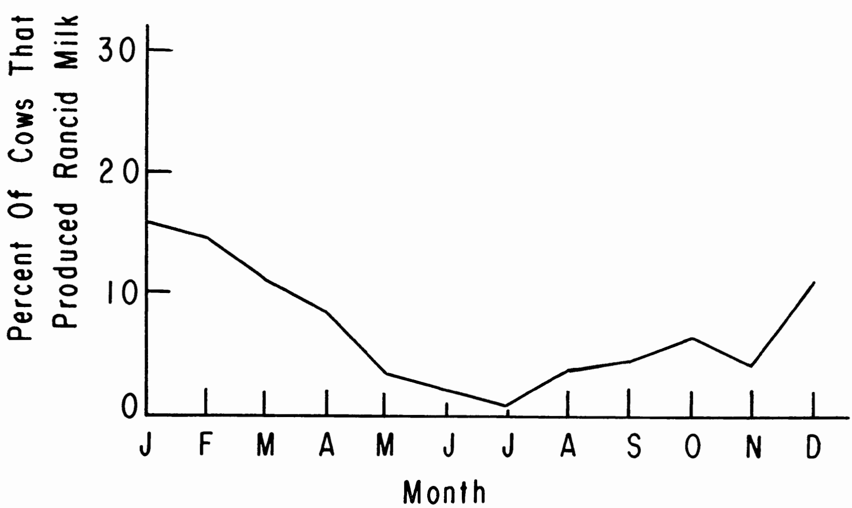

Figure 3. Influence of month of the year on rancid flavor in milk.

Outdoor Atmospheric Temperature

Since the incidence of rancid flavor appeared to be highest in cold weather, twelve cows were selected from the University herd to be used in a study of the effect of atmospheric temperature on FAD values. Sampling was started January 26, 1960 and continued into June.

Figure 4 shows average daily temperature plotted against average FAD values for the twelve cows, and also for the cow having the highest average among the twelve animals. Data shown are for the first 100 days of the study period.

No relationship was apparent between the average daily temperature and the average FAD value of all twelve of the cows used in this study; however, there appears to be a rather close relationship between

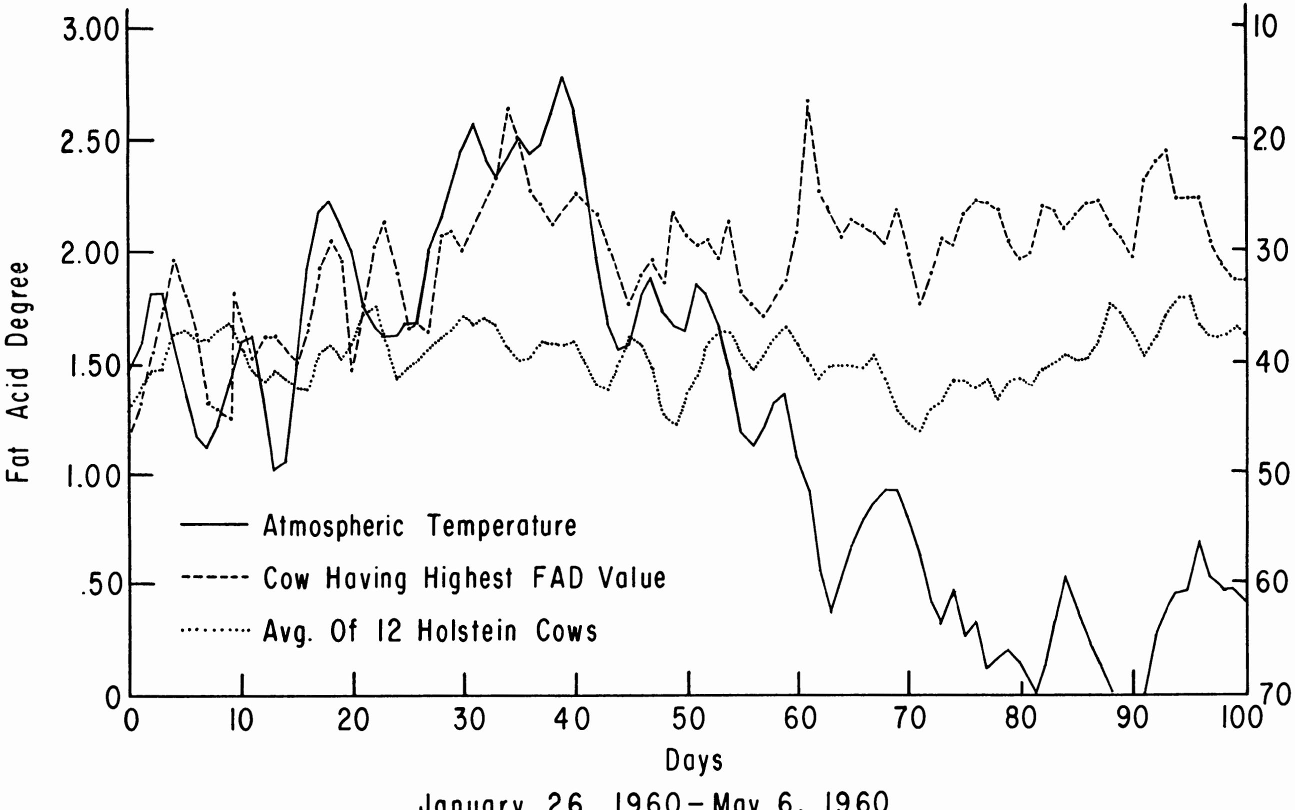

Figure 4. Relationship between outdoor atmospheric temperature and fat acid degree of milk.

the daily FAD value of the cow having the highest average, and the average daily temperature for the first 58 days of the study. From this limited study, it appears that cold weather might affect cows that are inclined to give milk with rancid flavor tendencies.

Cooling Procedure Experiments

By the end of 1958, the evidence that delay in cooling reduced the tendency of milk to develop rancid flavor became so strong that tests of farm milk-cooling procedures were undertaken. The purpose of this phase of the study was to compare the effects of immediate and delayed cooling of the first milk into the empty bulk tank on the development of a rancid flavor.

The first trial was made in cooperation with 19 dairy farms in the Stillwater milkshed. This was followed by a trial period in the Station's experiment barn.

Storage Temperature; Stillwater Milkshed

For immediate cooling, the dairymen turned the bulk tank on automatic operation prior to the beginning of the milking operation. For delayed cooling, the tanks were not turned on automatic operation until approximately one hour after the beginning of the milking operation. This procedure was carried out only during the first milking operation after the tank had been emptied. After the switch was set on automatic operation, it remained there until the tank was again emptied. These procedures were alternated over a 16-day period which provided four complete comparisons for each of the 19 dairy farms. The milk was picked up every other day. Samples were collected from each cooling tank by the tank truck driver and were delivered to the laboratory for analysis. The samples were analyzed on the same day that they were collected.

The data in Table VIII shows a close relationship between FAD values and the holding temperatures in the bulk tank. The average holding temperature on the six farms which had high FAD values was 35.0° F., and 37.6° F. for the 13 farms with the low FAD values.

Storage Temperature; Station Experimental Barn

The influence of storage temperature on the development of rancid flavor was studied in detail by changing the thermostat setting on one

Table VIII.—Effect of delayed cooling and holding temperature in bulk tank milk; Stillwater Milkshed.

Fat Acid Degree Value			Average Tank Temperature (degrees F.)
Normal Cooling	Delayed Cooling	Difference	
Farms with Rancid Flavor Problem			
2.20	1.62	0.58	34.0
3.95	3.01	0.94	33.0*
1.96	1.66	0.30	35.1
2.57	1.60	0.97	36.0
1.97	1.70	0.27	34.2
1.95	1.90	0.05	37.5
Avg. 2.43	**1.91**	**0.52**	**35.0**
Farms without Rancid Flavor Problem			
1.16	1.09	0.07	40.0
1.45	1.33	0.12	39.1
1.58	1.64	—0.06	36.1
1.29	1.24	0.05	36.0
1.53	1.40	0.13	36.1
1.00	1.16	—0.16	36.0
1.42	1.42	0.00	35.1
0.91	0.84	0.07	41.0
1.42	1.13	0.29	38.1
1.07	1.09	—0.02	36.4
1.56	1.47	0.09	38.2
1.69	1.24	0.45	37.6
1.18	0.89	0.29	38.7
Avg. 1.33	**1.23**	**0.10**	**37.6**
Total Avg. 1.68	**1.44**	**0.24**	**36.7**

*Average temperature reported by truck driver was 39.0°. Thermometer was found to read 6° high.

of the bulk cooling tanks on the Station's dairy farm. For eight days, the thermostat was set to maintain an average holding temperature of 34° F.; and for a second eight-day period, the average holding temperature was maintained at 39° F. During the next 12 days, the average holding temperature was alternated between 34° F. and 39° F. with each filling of the bulk tank.

A summary of FAD values for the holding temperature study is shown in Table IX. The average FAD value for all milk delivered when the holding temperature averaged 34° was 2.32. The average FAD value decreased to 1.68 when the holding temperature was 39° F.

Table IX.—Effect of bulk tank holding temperature on lipolytic activity; Station Experimental Barn.

Sampling Date		Fat Acid Degree Value		
		33-35° F.		38-40° F.
2-27-59		2.51		
3-1-59		2.62		
3-3-59		1.91		
3-5-59		2.00		
	Average	**2.26**		
3-9-59				1.53
3-11-59				1.71
3-13-59				1.71
3-15-59				1.58
			Average	**1.63**
3-19-59		3.10		
3-21-59				1.55
3-23-59		2.68		
3-25-59				1.84
3-27-59		2.44		
3-29-59				1.86
	Average	**2.74**		**1.75**
	Total Average	**2.32**		**1.68**

Holding Temperature and Length of Holding Period

In all work up to and through the early part of 1959, all FAD value determinations were made after holding the milk for 48 hours at 35° F. Therefore, it was felt necessary to investigate the effect of varying the holding time and holding temperature.

For this study, 62 Holsteins in the University herd were used. Milk samples were collected from four cows each day until all 62 had been sampled. Immediately after each sample was taken, it was divided into nine portions. Within ten minutes after collection, two samples were cooled to each of four temperatures: 32°, 37°, 42°, and 47° F. One sample of each pair was analyzed after being held 24 hours, the other after being held 48 hours. The ninth sample was analyzed immediately.

Results of the analyses are summarized in Table X. These data show that FAD values increased as the temperature was lowered and the holding period was lengthened. This relationship is even more apparent in Figure 5, where the samples are grouped according to their degree of lipolytic activity. For the 15 cows whose milk had little or no tendency to develop a rancid flavor, there was little variation among temperatures or between the two holding times. But for the 10 showing high lipolytic activity, the effect of both time and temperature is clearly apparent.

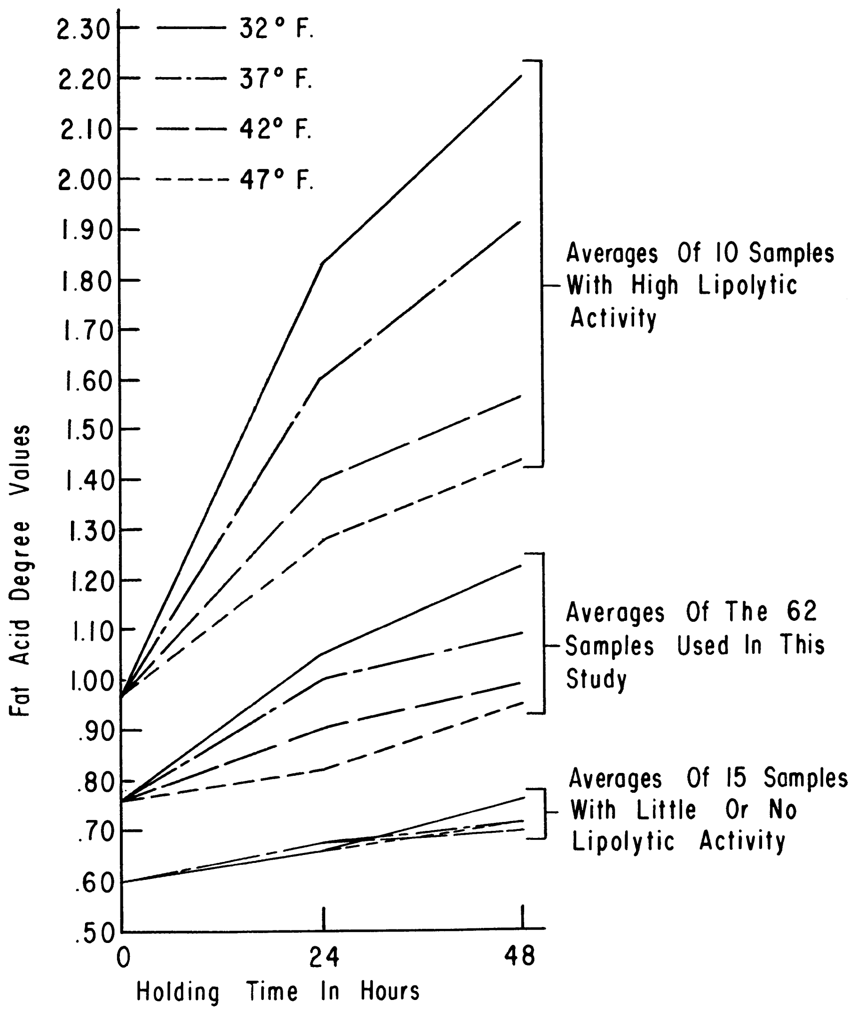

Figure 5. Effect of holding temperature and time on lipolytic activity in individual cow's milk.

Table X.—Relation of FAD value to time and temperature of holding milk.

	FAD Value		No. of Samples Having FAD Value of 2.00 or More
	Average*	Range	
Fresh milk	**.76**	**.44 - 1.35**	**0**
After 24 hours at:			
32° F.	1.05	.56 - 2.62	2
37° F.	1.00	.51 - 2.04	1
42° F.	.90	.53 - 1.71	0
47° F.	.82	.49 - 1.64	0
After 48 hours at:			
32° F.	1.22	.60 - 3.07	6
37° F.	1.09	.56 - 2.27	3
42° F.	.99	.49 - 2.03	1
47° F.	.95	.56 - 1.78	0

*Average of 62 cows sampled.

The Cow and Her Environment

After the study using the 62 Holsteins was completed, sampling was continued on the milk produced by 12 of the cows. The 12 cows were selected for various stages of lactation, levels of production, and lipolytic activity tendencies. Daily samples were taken from the afternoon milking over a period of 155 days, from January 26, 1960, through June 30, 1960. The samples were divided immediately into three portions. One was analyzed within an hour after collection. Another was cooled immediately to 32° F., and held at that temperature for 48 hours before being analyzed. The third was cooled immediately at 42° F. and stored 48 hours before analysis.

Variation Among Individual Cows

The summary of the individual-cow data presented in Table XI shows the great variation among the animals. There were also wide day-to-day fluctuations in the FAD values of samples from the same cow. This is illustrated by Figure 6 showing day-to-day variation over a 100-day period for the two cows which had the highest and lowest average FAD values for samples stored at 32° F.—no. 48 and no. 93, respectively (Table XI).

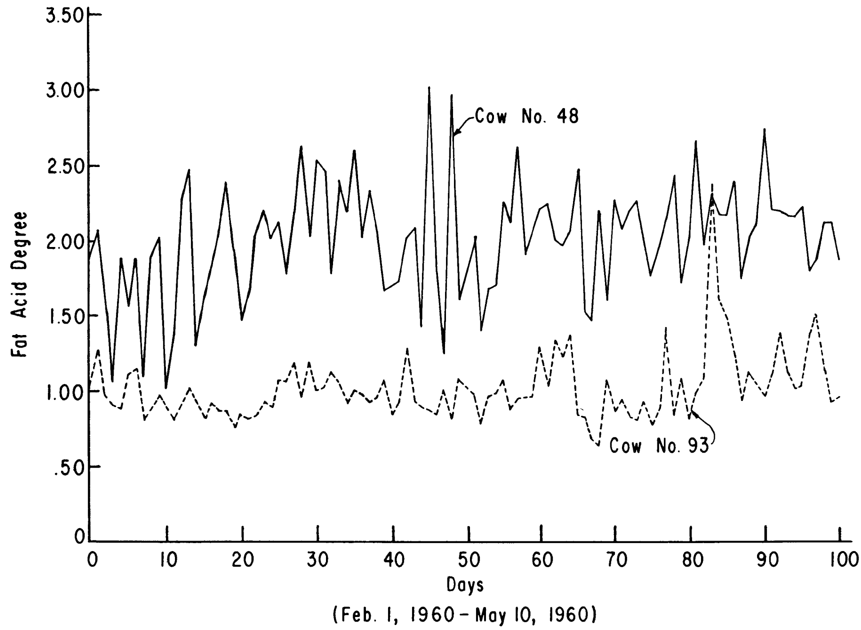

Figure 6. Daily fluctuation in fat acid degrees of the milk from two individual cows over a 100-day period.

Table XI.—Effect of two holding temperatures on average FAD values for individual cows during a 155-day period.

Cow No.	Fat Acid Degree Value							No of samples having FAD of 2.00 or more	
	Fresh	Highest		Lowest		Average			
		32°	42°	32°	42°	32°	42°	32°	42°
41	.88*	3.44	3.90	1.07	.93	1.80	1.64	56	29
47	.64	1.87	1.58	.62	.62	1.07	.94	1	0
48	.72	3.00	2.60	.98	.89	1.99	1.44	77	18
49	.63	2.44	2.44	1.16	.77	1.85	1.49	66	23
75	.75	1.91	1.47	.82	.80	1.37	1.11	3	0
78	.68	2.18	2.00	.98	.89	1.68	1.26	46	3
86	.72	2.42	1.85	.77	.73	1.62	1.16	44	1
89	.68	2.02	1.29	.66	.64	1.07	.89	0	0
91	.68	2.18	1.44	.84	.66	1.57	1.12	28	0
93	.68	2.40	1.38	.60	.62	1.01	.88	1	0
96	.63	2.66	2.49	.77	.67	1.69	1.52	59	16
113	.76	2.06	1.78	1.11	.93	1.49	1.22	7	0
Avg.	**.70**	**2.38**	**2.02**	**.87**	**.76**	**1.52**	**1.22**		
							Total	388	90

*Completed lactation during period of study.

Holding Temperature

The data in Table XI also re-emphasized the effect of storage temperature. Of the 478 samples having a FAD value of 2.00 or more, 388 were from the group stored at 32° F.

Interrelationship of Level of Production and Stage of Lactation

Figures 7 and 8 show the interrelationship between stage of lactation, level of production, and tendency of the milk to develop rancid flavor in the cases of two cows, nos. 89 and 91 (see Table XI). When sampling was started, no. 89 was in her 41st week of lactation and no. 91 in her eighth week, but both were producing approximately 30 pounds of milk per day. Number 89's production held up rather well, despite her advanced stage of lactation, and the weekly average FAD values of her samples never exceeded 1.41. Number 91's production fell off sharply after her 23rd week of lactation; and, simultaneously, the FAD values of her milk samples shot sharply upward.

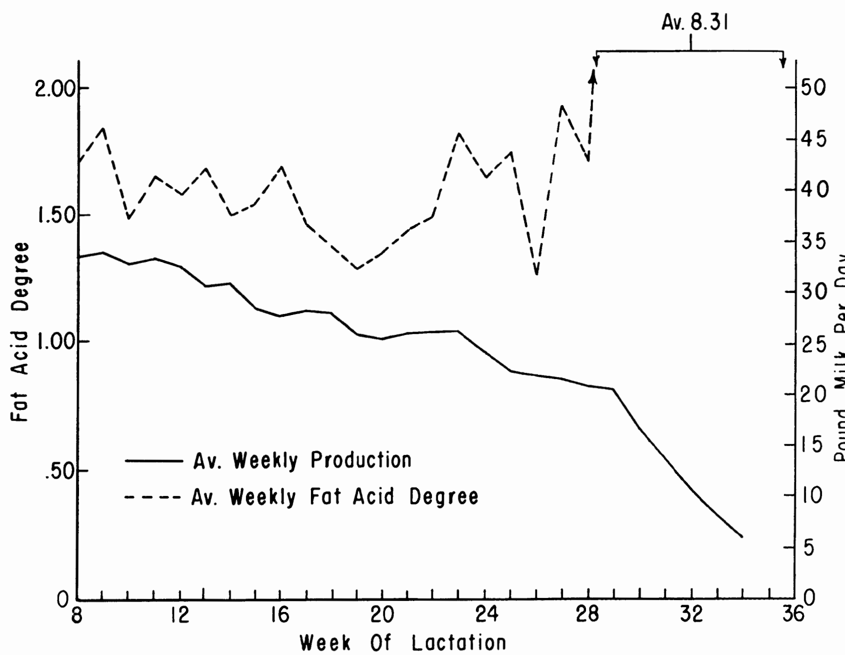

Figure 7. Relationship between production trends and the fat acid degree of the milk of Cow No. 91.

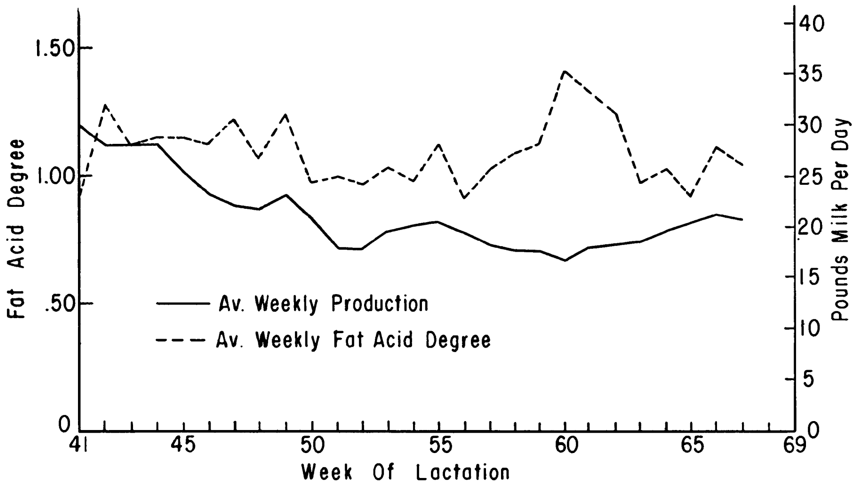

Figure 8. Relationship between production trends and the fat acid degree of the milk of Cow No. 89.

Effect of Feeding Sorghum Silage

Reports from dairy farmers and dairy plant field men suggested that heavy feeding of sorghum silage might be related to the development of rancid flavor. Therefore, a double reversal feeding trial was set up in March of 1960, using two groups of four Holstein cows each. All the cows were receiving alfalfa hay and sorghum silage as roughage before the trial started. During the trial, the groups received either hay or silage as indicated in Figure 9. Samples for analysis were taken daily from the afternoon milking of each cow.

FAD values were as shown in Figure 9. Apparently there was some relationship between the feeding of this silage and the FAD values of the milk. The delayed response in the third feeding period may be due to the fact that during this period both groups of cows were on green pasture as well as receiving the experimental ration.

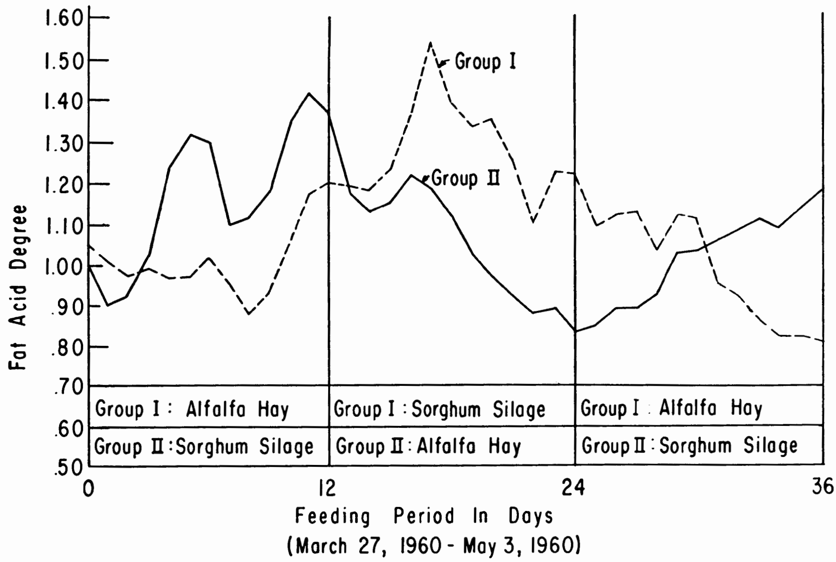

Figure 9. Influence of feeding sorghum silage on fat acid degree in milk.

Summary and Conclusions

The problem of rancid milk on dairy farms was approached from several angles, including surveys of operations on dairy farms, and controlled studies with the University dairy herd.

These studies were conducted to determine the effect of certain factors on the rancid flavor, or Fat Acid Degree values (FAD), in milk. Factors investigated included length of time before cooling milk, holding temperature of the milk, and length of holding period. In addition, season of the year, atmospheric temperature, level of production, stage of lactation, and the effect of feeding sorghum silage, were tested for possible influence on rancidity.

Factors involving the cooling and holding operation appeared to have an important effect on rancid flavor. Results from the studies suggest that FAD values would be less if cooling is delayed approximately one hour, and milk is held at a moderate temperature of 38° to 42° F. FAD values increased as the temperature was lowered and the holding period lengthened. This was particularly apparent for cows showing high lipolytic activity.

Stage of lactation also appeared to influence the incidence of rancid flavor. Cows in the later stages of lactation averaged much higher FAD values than cows in earlier months. This was also pointed out in the level of production studies conducted on individual cow samples. As level of production increased, the average FAD values consistently declined.

The rancid flavor problem was found to be most acute during the winter months. FAD values were highest during December and January, and were lowest during July.

In summarizing individual cow data, there was wide variation in FAD values among animals. There was also wide day-to-day fluctuation in samples from the same cow.

Feeding trials were set up to determine if there is a relationship between feeding sorghum silage to the cow and the degree of rancidity in the milk. Data from this study indicate an increase in FAD value when sorghum silage is included in the dairy ration.

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