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Methylene Blue Quality of Summer Produced Manufacturing Milk

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SUMMARY

A study of milk quality in 16 plants receiving manufacturing grade milk in north Missouri was made during the months of June, July, and August, 1961.

More than 52 percent of the producers who shipped milk used mechanical coolers. This group of producers shipped milk of significantly higher quality than those whose milk was not cooled mechanically. In fact, the study showed one hour's greater reduction time can be expected for samples from milk that is mechanically cooled.

General milk quality was lowest during the month of July.

About 3 percent of the producers shipped milk of probational quality long enough to require rejection of further shipments.

Air temperatures had a significant effect upon milk quality. This was especially true of non-cooler milk, for which it was shown that an increase of 10°F in either the day-time high or night-time low temperature would result in a decrease of over 30 minutes in the reduction time for the milk. The effect upon cooler milk, while significant, was much less pronounced and concerned itself primarily with the day-time high temperature which could be held responsible for a decrease of 20 minutes in reduction time for every 10°F rise in temperature. A rise of 10°F in the night-time low caused a decrease of 15 minutes in reduction time. However, it is suspected that this factor really reflects the higher succeeding day-time temperature and that the principal degradation of cooler milk quality is caused by high transportation temperatures.

There was no significant difference in quality of milk shipped by non-cooler patrons when compared as to volume of production. There was, however, a significant correlation between volume of shipment and quality for producers who used mechanical coolers. Larger producers were more likely to ship better quality milk.

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INTRODUCTION

An intensive program of quality research under the sponsorship of the Milk Quality Improvement Association of North Missouri and the Missouri Department of Agriculture, and directed by the Dairy Department of the Missouri Agricultural Experiment Station was completed during the months of June, July, and August, 1961. Two dairy manufacturing students served as technicians after having received training in the performance of the tests.

Tests were made on each producer's milk twice monthly. The procedure as outlined in the Standard Methods for the Examination of Dairy Products, eleventh edition, was followed. However, reading times were modified so that grading standards listed in the State Dairy Law could be followed. These standards are as follows:

Bacterial Estimate Classification	Methylene Blue Reduction Time (hours)
1	More than 3½
2	2½ to 3½
3	½ to 2½
4	Less than ½

In addition to these required readings, one was taken after one and one-half hours incubation.

Sixteen north Missouri manufacturing plants participated in the study. The average number of producers per plant ranged from less than 100 to nearly 2000; however, the majority of plants had from 300 to 500 patrons. About 7,500 samples were tested each two-week period. For various reasons not all producers had samples tested each period. Only data representing four or more test periods have been used in the statistical analyses. The data represent tests on milk from 6,356 producers.

Objectives of the program were as follows:

(1) to assess the effect of various factors upon the milk quality,
(2) to discover the relative quality of milk delivered, and
(3) to aid in standardization of test procedures in the participating plants.

RESULTS AND DISCUSSION

Data available at each plant were used to assess the effects of various factors upon the test reduction time. Use of mechanical milk coolers, volume of milk delivered daily by the producer, and high day-time and low night-time temperatures were the factors studied.

Effect of Mechanical Cooling

Fifty-two percent of the producers used mechanical coolers. This group supplied approximately 69 percent of the total milk quantity.

These patrons, on the average, delivered milk of higher quality. That this is true is indicated by Figure 1, which plots the mean methylene blue reduction times for patrons of both cooler and non-cooler categories for each test period. Here the test periods correspond to nine-day intervals taken from the first and last halves of each month beginning the first half of June and ending the last half of August. This figure shows that on the average there was about one hour longer reduction time for milk which was mechanically cooled. In fact, the over-all average reduction time for all patrons in each class, 1.76 for non-cooler and 2.78 for cooler patrons, is separated by almost exactly one hour. The bulk of this mechanically cooled milk would be placed in Class 2 according to the Missouri

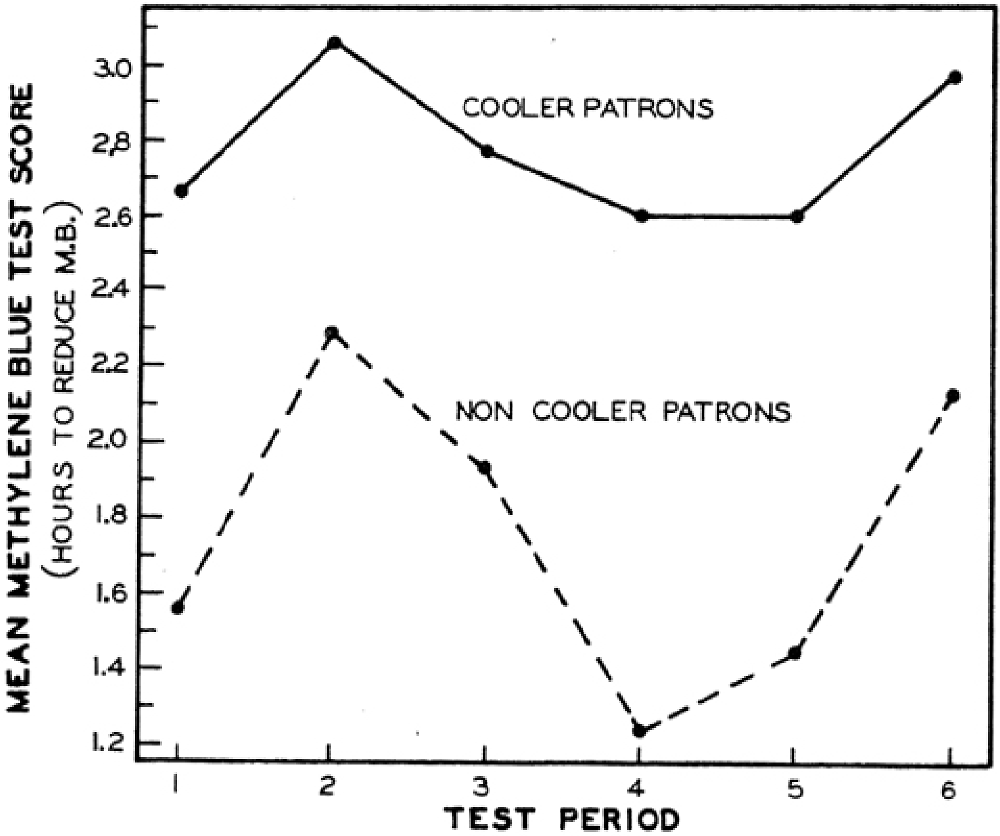

Fig. 1—Average time required to reduce methylene blue per test period (June through August) for cooler and non-cooler milk.

Dairy Law, while the bulk of milk from non-cooler patrons would be placed in Class 3. The reduction time that separates Classes 2 and 3 is 2.5.

The differences between the average test scores for cooler and non-cooler patrons for each test period were highly significant ($P<0.01$).

The graph does not show how individual producer samples were distributed around the means. Calculation of the standard deviation for each category of producer showed essentially the same value for both (1.58 for non-cooler and 1.60 for cooler). This can be interpreted to mean that factors other than cooling temperature exert the same degree of influence upon the milk quality of both cooler and non-cooler patrons. Such is further indicated by the similarity between the curves plotted on the graph, which show the same quality trends for both groups of milk.

The standard deviation values mean, furthermore, that there was quite a wide variation in quality of samples whether from the cooler or non-cooler sources. In both cases two-thirds of the observations fell within $\pm$ 1.6 hours of the average reduction time. These boundaries are from about 1.2 to 4.4 hours for cooler milk and 0.2 to 3.4 hours for non-cooler milk.

Effect of the Dairy Law

The marked improvement in quality indicated by the rise of both lines in Figure 1 between periods one and two probably reflects the concern of both producer and processor in the quality scores of the first test series, which showed that nearly 33 percent of the producers delivered probational milk. Reports from the milk plants indicated an extensive program of clean-up in many instances.

The decline in quality beginning in early July probably reflects the influence of higher temperatures.

The very marked improvement in quality at the end of the test series may have been due to the lower temperatures which occurred, or to more producer chore time or other such factors. However, it might also be postulated that the Dairy Law itself was responsible for the improvement since no patron could sell probational milk, that is, milk classified No. 4, continuously, for more than ten weeks. Test six was performed ten weeks after test one. To determine whether the Law had this effect, data on the producers whose milk was of probational quality during the first four test periods were sorted out for study. The situation is depicted by Table 1. The total number having Class 4 milk was 326. Of this number, 130 improved their milk enough to have it at least classify as No. 3 at the time of either test 5 or 6. The remaining 60 percent failed to improve quality, and, consequently, 196 patrons were subject to having their milk rejected. This number amounts to 3.3 percent of the total milk producers.

Since the number of producers who were obligated to improve their milk quality or have their milk rejected amounted to only 5.4 percent and only 40 percent of this group did improve the quality, one could hardly say that the Dairy Law was the direct cause of the marked improvement in late August.

TABLE 1 - AUGUST DISTRIBUTION OF PATRONS WHO SHIPPED PROBATIONAL MILK DURING JUNE AND JULY

Test Period	Classification	Number of Producers	Percent of Total Producers
1, 2, 3, & 4 (June and July)	No. 4 (Probational)	326	5.43
5 or 6 (August)	Improved to No. 3 or better	130	2.17
5 and 6 (August)	No Improvement No. 4 (Probational)	196	3.26

Effect of Outside Air Temperatures

Since the temperature of the cooling medium used in non-mechanical coolers should be directly influenced by air temperatures, and since the degree of milk warm-up during transportation should be likewise affected, the high daytime temperature for the day delivered and the low night-time temperature for the night previous to delivery were recorded, then related to over-all quality. Samples were also classified as to method of cooling.

Figure 2 shows results of the analysis of data for mechanically cooled milk.

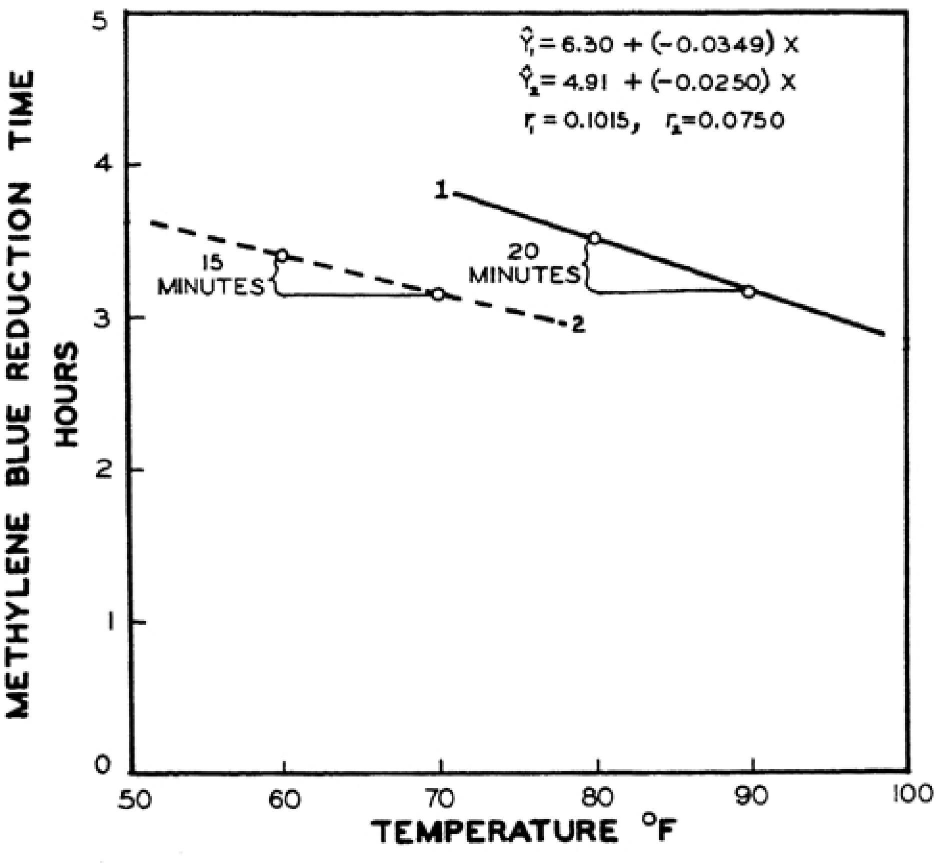

Fig. 2—Expected changes in reduction time with changes in (1) day-time high and (2) night-time low temperatures. Mechanically cooled milk.

Line 1 represents the decrease in reduction time that was indicated with increases in day-time maximum temperature for cooler milk. Line 2 shows the same information as related to minimum night-time temperature. The correlation between both maximum and minimum temperatures and milk quality is highly significant ($P < 0.001$) although the highest degree of correlation was between day-time temperature and reduction time.

It can be expected, according to this evaluation, that with each 10°F rise in maximum daily temperature, cooler milk will reduce methylene blue some 20 minutes sooner. Likewise, for each 10°F rise in minimum night-time temperature a decrease of about 15 minutes should result.

The difference in slope of these two lines was shown to be statistically significant, which means that high day-time temperatures are more injurious to quality of cooler milk than are high night-time temperatures. The shallow slope of line 2 emphasizes the importance of the hauling factor upon quality of cooler milk.

Figure 3 shows the effect of temperature maxima and minima upon non-cooler milk. Line 3 represents the quality values in relation to the day-time high, and the lower line (line 4) those for the night-time low. Here, again, the correla-

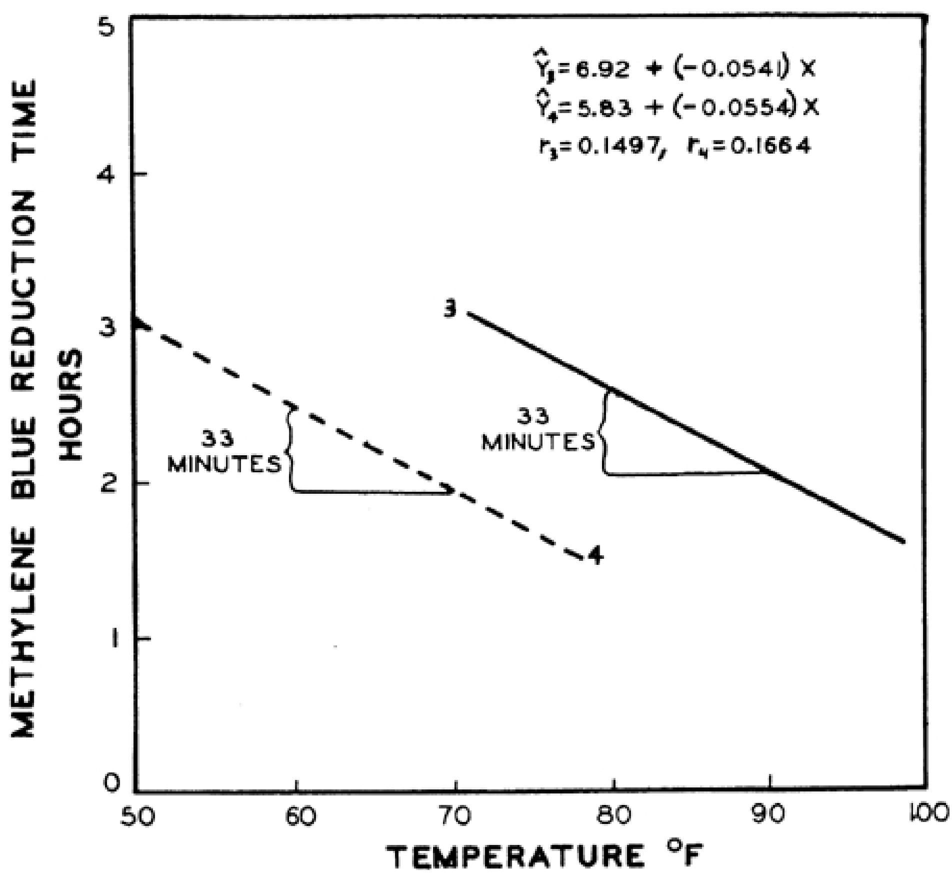

Fig. 3—Expected changes in reduction time with changes in (3) day-time high and (4) night-time low temperatures. Milk not mechanically cooled.

tion of temperature to quality is highly significant (P<0.001). There is no statistically significant difference between the slope of these lines; therefore, it cannot be said that high day-time temperatures have any greater effect on non-cooler milk than high night-time temperatures as was the case of cooler milk.

The slope of these lines also indicates that for each 10°F rise in temperature maximum or minimum, we can expect a decrease in reduction time of slightly more than 30 minutes.

Figure 4 depicts how the high day-time temperatures affected cooler and non-cooler milk individually. The distance between the lines reflects, for the various temperatures, the differences in quality. It may be noted that the quality spread becomes wider as temperatures increase, so that at a high of 70°F the average difference in reduction time was about 45 minutes, while a high of 90°F resulted in a difference of over one hour. These quality differences were highly significant statistically (P<0.001).

The greatest difference in temperature effect occurred when expected cooler and non-cooler milk quality values were compared at the various night-time

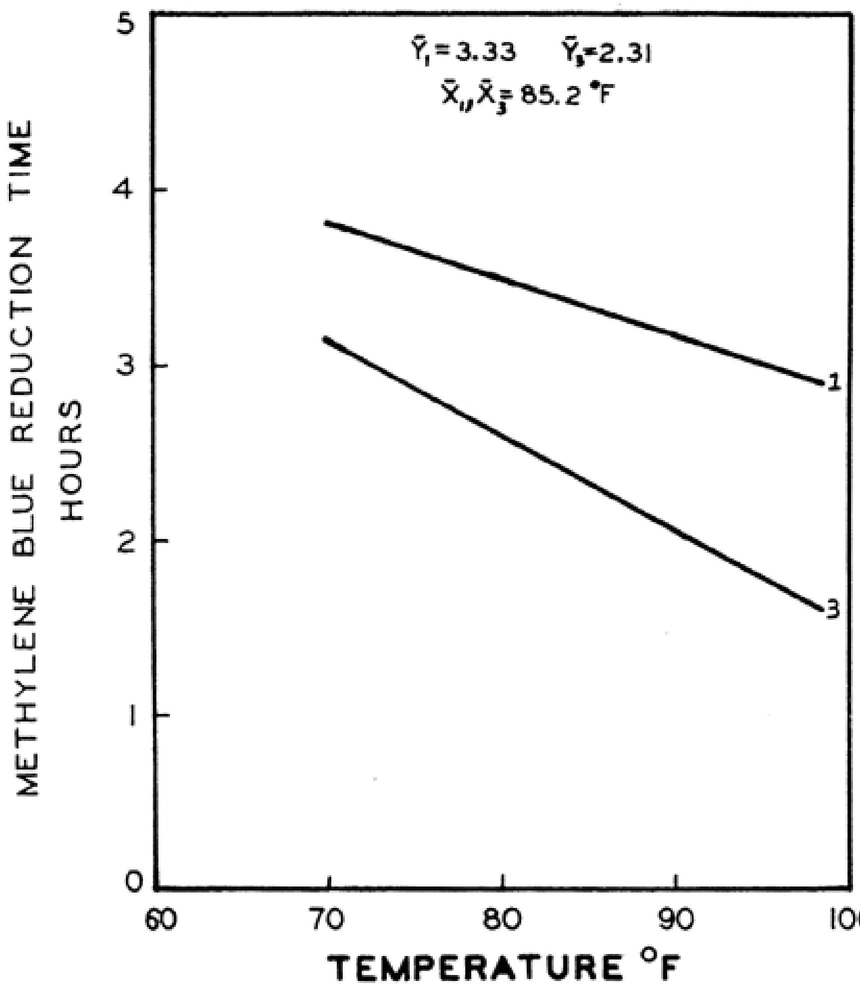

Fig. 4—Effect of high day-time temperatures upon reduction time for (1) mechanically cooled milk and (3) milk not mechanically cooled.

lows. Figure 5 indicates this relationship. Here the slope of the line for non-cooler milk is steep in comparison to that for cooler milk, so that while a low of 50°F would be expected to produce a difference of only 36 minutes, a low of 70°F would be expected to cause a difference of about one and one-fourth hours in reduction time. Here it is probable that the slope of the line for cooler milk is at least partially due to the fact that a high temperature existed the succeeding day and had an appreciable effect upon the milk while it was in transport. In fact, it is suggested that this was responsible for nearly all the decrease in quality.

Effect of Producer Volume

Because of the influence of better management practices upon milk volume, it was postulated that producers of large volumes of milk would ship better quality milk than small volume producers. To eliminate the pronounced effects of mechanical cooling the data were separated into the two groups, cooler and non-cooler.

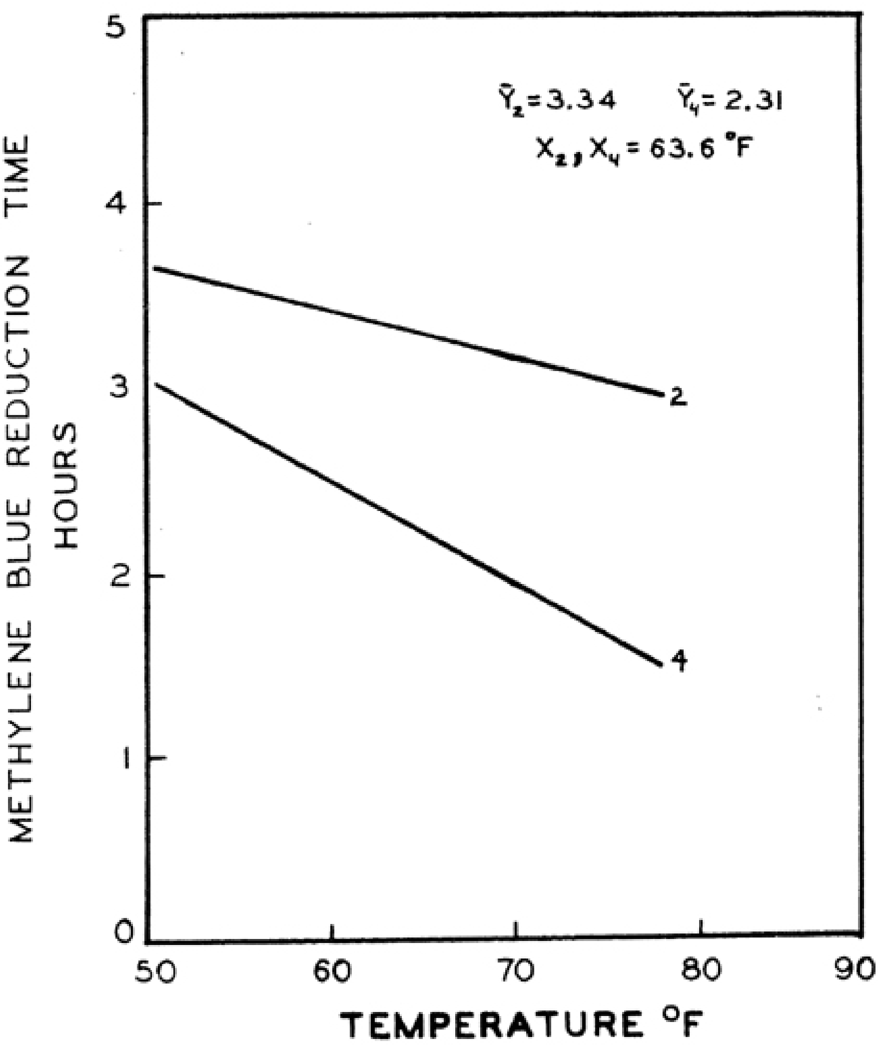

Fig. 5—Effect of low night-time temperatures upon reduction time for (2) mechanically cooled milk and (4) milk not mechanically cooled.

This division showed that most non-cooler patrons were very small producers. More than 2000 were in the 100 pound per day class and about 600 shipped approximately 200 pounds per day. Twenty shipped 300 pounds or more per day. There was no significant correlation between producer volume and quality of milk not mechanically cooled.

Producers who used mechanical coolers shipped more milk so that eight classes could be set up on the basis of hundreds of pounds shipped. The distribution of these producers by weights of milk they produced is shown in Table 2.

TABLE 2 - DISTRIBUTION OF PRODUCERS USING MECHANICAL COOLERS

Weight Class*	Number of Producers	Pounds Delivered by Class/Day	Percent Total Milk Delivered
1	877	87,700	12.1
2	920	184,000	25.4
3	572	171,600	23.7
4	307	122,800	17.0
5	146	73,000	10.1
6	76	45,600	6.3
7	20	14,000	1.9
8**	32	25,600	3.5
	2950	724,300	100.0

* Hundredweights milk delivered per producer per day.

** Includes a very few producers shipping more than 800 pounds per day.

More than 59 percent of the milk came from producers in weight classes 2 and 3.

There was a positive correlation between producer volume and quality of cooler milk as is shown in Figure 6. Both the correlation coefficient, r, and the slope, b, are highly significant ($P < 0.001$). This was considered an indication of better production practices on the farms where more milk was produced, though the correlation was of little practical significance since each hundredweight increase in volume resulted in only one minute increase in reduction time.

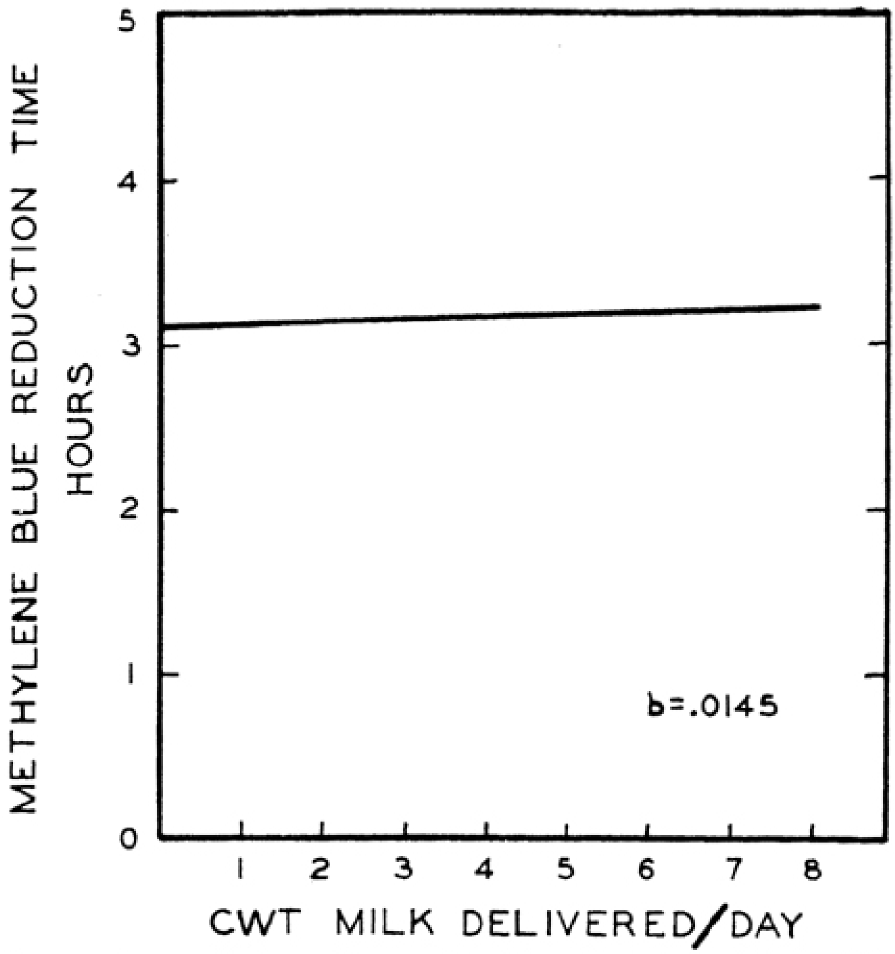

Fig. 6—Changes in methylene blue reduction time associated with hundredweights of milk delivered by patrons using mechanical coolers.

Quality of Milk by Volume

It has been stated that nearly 70 percent of the total volume was shipped by producers who had mechanical coolers. Table 3 shows how on an average day milk would have been distributed among the various quality classes. The bulk of the milk, 60 percent, would have fallen into Classes 3 and 4. All this milk reduced methylene blue in less than two and one-half hours. These data make obvious the need for an intensive program of quality improvement among producers of manufacturing grade milk.

TABLE 3 - POUNDS OF MILK RECEIVED IN THE VARIOUS QUALITY CLASSES ON AN AVERAGE DAY

	Pounds/Class	Percent/Class
Cooler Milk:		
Class 1	235,900	32.1
Class 2	107,000	14.5
Class 3	255,500	34.7
Class 4	137,600	18.7
	736,000	
Non-Cooler Milk:		
Class 1	50,900	15.5
Class 2	32,400	9.8
Class 3	124,100	37.7
Class 4	122,000	37.0
	329,400	
Over-all Average:		
Class 1	286,800	26.9
Class 2	139,300	13.1
Class 3	379,500	35.6
Class 4	259,600	24.4
	1,065,300	

* Class - Bacterial Estimate Classification