THE EFFECT OF HOLDER AND FLASH PASTEURIZATION ON SOME FLAVORS OF MILK

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Robert D. Mac Curdy
1939

THE EFFECT OF HOLDER AND FLASH PASTEURIZATION ON SOME FLAVORS OF MILK

BY

ROBERT DOUGLAS MAC CURDY

1939

THE EFFECT OF HOLDER AND FLASH PASTEURIZATION ON SOME FLAVORS OF MILK

A THESIS

Submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfilment of the requirements for the degree of Master of Science.

Department of Dairy Husbandry

1939

THESIS

ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to the Dairy Industries Supply Association, Inc. for the fellowship which made this study possible, and to Dr. G. M. Trout, Associate Professor of Dairy Manufacturers at Michigan State College for his aid in directing this study.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	2
The effect of feeds on the flavor of milk.	2
The effect of aeration on the flavor of milk.	8
The effect of heat treatment on the flavor of milk.	10
Miscellaneous methods of flavor improvement	13
PURPOSE OF THE EXPERIMENT. PART I.	15
EXPERIMENTAL PROCEDURE	17
Pasteurization with and without aeration.	17
Flash pasteurization.	18
Judging the samples	18
RESULTS	20
Flavor quality of the raw milk used in this experiment.	20
Flavor quality of the milk holder pasteurized without aeration.	26
Flavor quality of the milk holder pasteurized with aeration.	30
Flavor quality of the milk flash pasteurized.	35
Flavors tending to increase or decrease as a result of pasteurization.	41
Reliability of flavor judgments	44
Development of oxidized flavors in the milk during the period of the study.	51
DISCUSSION	53
SUMMARY	57
PURPOSE OF THE EXPERIMENT. PART II.	61
EXPERIMENTAL PROCEDURE	62
Collecting silage flavored milk samples.	62
Holder pasteurization with and without aeration.	62
Holder pasteurization under vacuum.	62
Holder pasteurization with forced aeration.	63
Judging the samples.	64

RESULTS 65

Effect of various methods of pasteurization upon removing feedy flavor of corn silage flavored milk. 66

Effect on the score and flavor when passing the vapors from corn silage milk during pasteurization through cold silage flavor-free milk. 68

Effect of various methods of pasteurization upon the removal of alfalfa silage flavor from the milk. 71

Effect upon the score and flavor of passing the vapors from alfalfa silage milk through cold silage flavor-free milk. 74

DISCUSSION 75

SUMMARY 79

LITERATURE CITED 81

INTRODUCTION

Feed has long been recognized as a possible contributing factor to the flavor of milk. Early studies on the effects of feeding practices, as well as the feeds themselves, were made and much data have been presented. As a consequence, certain feeding rules have been established, which, when followed, result in a minimum of feed flavors in the milk produced. However, much feedy milk is produced at certain seasons. Many dealers and milk buyers have rejected milk bearing some feed flavors because they believed that the resulting milk supply would be "off flavored."

On the other hand, relatively little data are available to show the effect of pasteurization in its various forms upon the feed flavors of milk, particularly upon the flavor and score of the pasteurized milk as compared to the flavor and score of the raw milk. The purpose of this study is to show the effect of low temperature and of high temperature pasteurization upon the flavor and score of the milk as compared to the flavor and score of the original raw milk. Particular stress is placed upon the effects of the various methods of pasteurization on the feed flavors in an effort to determine if feed flavors resulting from the feeding of clean wholesome feeds, such as silage and alfalfa, are seriously objectionable to the market milk supply.

REVIEW OF LITERATURE

The effect of feeds on the flavor of milk

Over a century ago, William Harley (1829) of Scotland emphasized the importance of carefully selected feeds for the cow and stressed the evil effects of certain feeds on the flavor of milk.

Sixty-three years later, Fleischmann (1892) advised the addition of small quantities of aromatic herbs to cows' winter rations ---- presumably to improve the flavor of milk.

Soon thereafter, King and Farrington (1897) published an excellent piece of work explaining the physiological cause of flavor in milk. They concluded, in part, as follows: "Whenever a cow eats any substance containing a volatile principle, which is not digested or which in the process of digestion produces such a substance, then this will be removed from the blood by the various chemicals of excretion. If the cow is being milked while a portion of these volatile products are in the blood, a portion of them will be removed and impart an odor or flavor or both to the milk. However, if fed when not milking they will be carried off to the lungs, kidneys, anus, skin, etc. and the intensity of the milk flavor will be lessened. Milk will absorb a silage odor from standing in a pail close to a silo, but silage odor enters milk more rapidly through the cow than through the milk by absorption."

After this knowledge had become general, research workers began investigate particular feeds to determine which ones were harmful to

the flavor of milk. From 1915 on to the present day, many of the common and uncommon feeds and weeds which the dairy cow was likely to encounter were employed in feeding trials to note their effect on flavor. As a consequence, feeding rules were established to prevent milk being "off flavored".

Kellner (1915) as cited, believed that certain feeds, for example, "good meadow grass" improved the flavor of milk. Gray and Eaton (1916), (1917), working with onion flavored milk discovered that the flavor of onions was present in two per cent of the samples twenty minutes after the cow had eaten the onions. The highest onion flavor was noted within two to two and one-half hours and disappeared within four to four and one-half hours. They isolated the causative chemical of the onion flavor and found it to be allyl sulphide. They discovered that feeding molasses feeds decreased the onion flavor of the milk.

From this stage in the knowledge of feed flavors, experiments were conducted to determine periods of feeding time in which feeds could be fed without producing off flavored milk. Gamble and Kelly (1922) showed that when silage was fed one hour before milking the odor was present in the milk produced. They found that legume silage affected the flavor and odor of the milk more than did an equal amount of corn silage. Moderate quantities, thirty pounds, of corn silage fed directly before milking produced a very strong feed flavor in the milk. Soy bean silage was found to have the same effect as alfalfa and corn silage.

Riddet and Valentine (1923) reported that certain weeds produced characteristic taint in milk. Among them were: Pennyroyal (Mentha pulegium), land crest (Coronapus didimus), watercress (Nasturtium), buttercups (Ranunculus). The taints produced in milk by them were very

pronounced.

Babcock (1923) found that feeding as much as thirty pounds of green alfalfa, one hour after milking, produced no feed flavor. In fact, the flavor was better than milk from cows which had received no alfalfa. Likewise, removal of cows from pasture five hours before milking prevented pasture off flavors. Feeding green corn one hour before milking had only a slight effect on flavor, whereas there was no effect on flavor when fed after milking. He, therefore, concluded that twenty-five pounds of green corn could be fed up to an hour before milking without producing any objectionable flavor.

Later Babcock (1924) showed that feeding 14.3 pounds of cabbage an hour before milking resulted in a very strong objectionable flavor in the milk. However, 14.8 pounds of potatoes fed an hour before milking produced a very slight odor and flavor, yet were undesirable. He (1925a) found that feeding 15 pounds of green rye one hour before milking produced only slight odor and off flavor, whereas feeding 30 pounds produced an objectionable odor and flavor. Feeding green cowpeas in the same amounts one hour before milking produced a greater intensity of off flavor, whereas the same amounts of green rye and green cowpeas fed after milking produced no objectionable flavor. Working with garlic feeds, he (1925b) found that the flavor passed into the milk within one minute after feeding. The period of highest intensity of garlic flavor in the milk was ten minutes after feeding. One-half pound of garlic consumed four hours before milking produced a very undesirable flavor; in seven hours after feeding garlic, the flavor practically disappeared from the drawn milk. Inhalation of garlic odors only, without feeding, resulted in a garlic flavored milk within ten minutes of

breathing the vapors. As the time interval between inhalation and milking increased, the flavor intensity decreased and finally disappeared within 90 minutes. Working upon the effect of some succulent feeds on the flavor and odor of milk, he (1927) found that the following had no effect upon flavor and odor of milk when fed one hour before or one hour after milking: dried beet pulp soaked and fed up to thirty pounds, pumpkins, and sugar beets. The following had but very little effect when fed one hour before milking and no effect when fed one hour after milking; green oats or peas up to thirty pounds, and carrots up to thirty pounds. The following produced a decidedly abnormal flavor when fed an hour before milking: rape up to thirty pounds, kale up to thirty pounds. Neither had any effect when fed an hour after milking. Soy beans fed to cows an hour before milking (feeding up to thirty pounds) had a tendency to improve the flavor and odor of the milk.

Babcock (1930) summarized all his work on abnormal flavors. He believed that all off flavors in milk could be classified as follows:

(1) Physical condition of the cow, such as salt, rancid.

(2) Biological changes in milk, acid, putrid, bitter, fruity, nutty.

Or chemical changes, oxidized, fishy, rancid.

(3) Absorbed odors, such as gases, organic or inorganic type.

(4) Feeds and weeds consumed, such as silage (legume-corn), sweet clover, french weed, green cowpeas, potatoes, dried beet pulp, carrots, garlic, bitterweed, soybeans, green alfalfa, cabbage, turnips, rape, kale, green rye.

Trout (1932), working with a large number of milk samples, noted cases of silage flavor reported were caused by feeding just before milking.

Roadhouse and Henderson (1932) concentrated the flavor producing material of feeds by freezing feeds and extracting the liquids by means of a hydraulic press. A standard drench was produced by extracting the liquid from twenty-five pounds of frozen, chopped, and pressed feed. This liquid was usually equal to about five to six quarts. They found that by drenching the cows with this quantity of juice, the feed flavors appeared in the milk twenty minutes after drenching. The flavors were most pronounced in the milk drawn from forty-five to sixty minutes after drenching.

Weaver et al. (1934), working with alfalfa hay, found that feeding four pounds before milking impaired the flavor score of the milk samples as follows:

Feeding ½	hr.	before milking lowered the score of the milk	2.3 points
" 1	"	" " " " " "	3.2 "
" 2	"	" " " " " "	3.4 "
" 3	"	" " " " " "	2.7 "
" 4	"	" " " " " "	1.5 "
" 5-7	"	" " " " " "	.6 "

Roadhouse and Henderson (1937) found that cows could be fed all the alfalfa hay they would eat up to 5 hours before milking and produce no off flavor.

Trout and Taylor (1935), while working on beet top flavored milk, found that no flavor trouble need arise from normal feeding of clean high quality beet tops when the rules of good feeding practices were followed, but feeding over twenty-five pounds of beet tops per day was likely to result in off flavored milk. Feeding at milking or slightly

before had more harmful results than feeding after milking. Feeding decomposed or frozen beet tops had a detrimental effect. Beet top flavor did not become pronounced enough to merit refusal from market milk until cows were fed almost entirely upon beet tops. They believed that most mild beet flavors would pass unnoticed if the average consumer drink the milk cold.

Roadhouse and Henderson (1935) found that feeding concentrates gave little off flavor to milk. They stated: "Concentrates, rolled barley, coconut meal, cotton-seed meal, wheat bran, dried beet pulp when fed one to two hours before milking in average feeding quantities did not produce a sufficient off flavor to make milk undesirable. Rolled barley, beet pulp did give a pronounced flavor, but the average person drinking milk with this intensity of flavor cold would not detect it. Wheat bran fed one to two hours before milking gave a desirable flavor".

Weaver et al. (1935) making 4,262 sample observations of milk, found the distribution of off flavors as follows:

	Per cent		Per cent		Per cent
Feed flavors	19.73	Sweet	0.87	Nutty	0.33
Cowy	15.49	Bitter	0.45	Cooked	0.31
Stale	8.47	Metallic	0.38	Watered	0.21
Rancid	10.39	Weedy	0.38	Acidy	0.09
Flat	4.65	Oxidized	0.35	Musty	0.02
Salty	4.67	Sharp	0.35	Disinfected	0.02

Trout (1937), examining a number of samples of raw milk on the first day and on the third day after bottling, found the following

distribution of flavor:

Flavor	Percentage distribution	
	First day	Third day
Clean	41.1	28.5
Feed	23.4	35.7
Lacks fine flavor	11.7	----
Rancid	11.7	35.7
Barny	5.8	----
Cowy	5.8	----
Total	99.5	99.9

The effect of aeration on the flavor of milk

Ayers and Johnson (1914) found that by blowing air through milk heated to 145°F. all the garlic flavors could be removed within thirty minutes. If the intensity of the garlic flavor were slight a shorter aeration period would be sufficient. They discovered that the method worked the same for cream if a longer period were maintained.

Gray and Eaton (1916), (1917), working with onion flavored milk, found that it was possible to remove the flavor of onion on a commercial scale by blowing a current of heated air through the milk for a length of time depending on the intensity of the onion flavor. The milk was held at a temperature of 140°F. to 145°F. during the blowing period.

Gamble and Kelly (1922), working on silage flavored milk, discovered that condensed milk made from silage tainted milk had a less perceptible silage odor than the milk from which it was made. Cream made from silage tainted milk had a more intense silage flavor than did

the original milk. Aeration over a surface cooler partially removed the silage flavor and odor. Milk tainted from absorbed barn odors was freed of these odors by means of aeration.

Riddet and Valentine (1933), working on weed flavored milk, found that certain weed flavors from such weeds as pennyroyal (Mentha pulegium), land crest, (Coronapus didimus), water cress (Nasturtium), buttercups (Ranunculus) could not be dispelled by cooling or aeration of the milk.

Babcock (1923) worked with green corn and green alfalfa flavors in milk and found that aeration over surface coolers of warm milk removed slight off flavors produced by those feeds. He (1924) found that proper aeration reduced strong and eliminated mild abnormal flavors in milk due to cabbage feeding.

Hunziker (1927) recognized three methods of removing off flavors by aeration: (1) treating cream as milk with air; (2) treating heated cream with air under a reduced atmospheric pressure; (3) replacing the air in the milk or cream by carbon dioxide. Of these methods, the latter was unsatisfactory.

Mac Donald and Crawford (1927), working with onion and garlic flavored milk, found that blowing air through it would remove part of the flavor, but the process injured the milk.

M'Candlish and Leitch (1932) found that milk silage flavors were reduced by effective aeration of the newly drawn milk. Weaver (1935) showed that aeration would remove about one-half the off flavors imparted to milk by alfalfa hay.

Trout and Taylor (1935) noted that aeration rendered the off flavor of milk,produced by feeding beet tops,less objectionable. The

New York State Agricultural Experiment Station (1936) reported that when feed flavors were present in milk as drawn from the cow, their intensities were lessened by cooling the milk at the farm over surface coolers.

The effect of heat treatment on the flavor of milk

The effect of pasteurization per se on the flavor of milk has commanded attention only recently. Riddet and Valentine (1923), working with weed flavored milk, found that milk tainted by pennyroyal (Mentha pulegium), land cress (Coronapus didimus), water cress (Nasturtium), buttercups (Ranunculus) produced objectionable off flavors that could not be dispelled by flash pasteurization at 150°F.

Mac Donald and Crawford (1927) found that the substances causing onion flavor and odor in milk were confined largely to the fat and could not be entirely, although partially, dispelled by boiling.

Tracy and Ruehe (1931),pasteurizing and cooling milk in glass bottles, found that with the exception of a few feed flavors, in practically all cases, the barn flavors in raw milk were partially or completely eliminated by pasteurization. Holding for over sixty minutes at pasteurizing temperatures produced a cooked flavor. Samples of raw milk showed a greater variety of flavors. They (1923) also discovered that oxidized flavors were more frequent in the pasteurized samples than in the raw samples and concluded that bacterial metabolism in raw milk was probably the reason for general absence of tallowy flavors in the raw milk. Lack of bacterial metabolism accounts in part for the general tendency of some pasteurized milk to become oxidized during the winter, especially in some dairies that are able to control

the bacteriological quality of their milk from production until it is placed in the bottle.

Marquardt and Dahlberg (1934) found also that milk containing feed flavors, when pasteurized, had a diminished intensity of feed flavors and a blended flavor to give less variety. Pasteurized samples developed a cardboard, old, or storage flavor more quickly than raw samples.

Trout and Taylor (1935) found, when working with milk tainted with beet top flavor, that pasteurization changed the flavor so that it could not be criticized as "beet top flavor" but that the pasteurization exposure did not improve the flavor to any appreciable extent.

The New York State Experiment Station reported that when feed flavors were present in milk as drawn from the cow, their intensity was lessened by pasteurization of the milk.

Sharp, Trout and Guthrie (1936), working with the flavor of pasteurized milk as compared to raw samples, found that pasteurization at 145°F. increased slightly the tendency to develop the oxidized flavor. Milk pasteurized at higher temperatures developed less of the oxidized flavor than did the raw milk or the milk pasteurized at 145°F.

Brown, Thurston and Dustman (1936 b), working on oxidized flavor development in relation to aeration, found that exposure of the milk to the air while passing over a surface cooler did not per se cause any greater development of oxidized flavor than did the passage of milk through an internal cooler.

Dahle and Palmer (1937) found that pasteurizing temperatures of 145°F. for thirty minutes and of 160°F. for five minutes enhanced the degree of oxidized flavor which might develop, whereas, removal of

oxygen from susceptible milk by replacement with nitrogen prevented the development of the oxidized flavor.

Trout (1937) found the percentage distribution of flavors in raw and in pasteurized milk to be as follows:

Raw Milk

Flavor	Percentage distribution	
	1 day	3 days
Clean	41.1	28.5
Feed	23.4	35.7
Lacks fine flavor	11.7	----
Rancid	11.7	35.7
Barny	5.8	----
Cowy	5.8	----
Total	99.5	99.9

Pasteurized Milk

Flavor	Percentage distribution	
	1 day	3 days
Clean	13.3	12.0
Cooked or heat	65.5	30.9
Oxidized	5.5	20.7
Metallic	1.1	5.2
Barny	4.4	----
Cowy	3.3	----
Unclean	1.1	9.6
Acidy	1.1	----
Stale	----	10.3
Flat	----	10.3
Sour	----	1.7
Total	99.7	99.7

Powell (1938) working on pasteurization methods and their resulting effect on flavor of stored cream, found that flash pasteurization at 165°F. prevented the formation of bitter flavors during a ten day storage period. During late spring and summer months flash pasteurization at 155°F. produced very fine flavored cream which could be stored for ten days at 35°F. without flavor change. Flash pasteurization above 165°F. imparted objectionable heated flavors to the cream.

Quinn and Burgwald (1933) concluded that the high temperature short time pasteurization imparted less "cooked" flavor to the milk than did the holder method.

Miscellaneous methods of flavor improvement

There have been various methods proposed in the past to improve the flavor of milk by removing the off flavor producing factors.

Mac Donald and Crawford (1927) showed that successive washing of cream by pure mineral oil and gravity separation of the mineral oil would remove all the onion flavor or odor of the cream. Later, Mac Donald and Glaser (1929), working on the cause of bitter flavor of cream, extracted a crystalline, non-volatile, colorless, and odorless substance that was the cause of the bitter flavor. This bitter flavor could not be removed by aerating or heating, but successive separation and restandardization with fresh clean skim milk and reseparation would wash out all this bitter flavor producing factor.

Trout (1938) showed the effect of homogenization on improvement of the existing milk flavor and prevention of the development of the oxidized flavor. However, the milk must be pasteurized immediately after or before homogenization to prevent development of rancidity. A

pressure of 1500 pounds was found to be effective in stabilizing the clean sweet fresh flavor of milk and preventing development of oxidized flavors. Other workers, Tracy, Ramsey and Ruehe (1933), Thurston, Brown, and Dustman (1936 a), Ross (1937), and Dahle and Palmer (1937) had earlier demonstrated the inhibiting action of homogenization on the development of the oxidized flavor.

Many workers have shown the effects of sanitary measures in production and manufacturing to prevent contamination of milk by bacteria, dirt, or metals in an effort to improve milk flavor. Some have found that the addition of vitamin concentrates has improved flavor, or prevented off flavor development. These investigators and the methods employed have not been included here because their work is entirely out of the scope of this study, namely, the effect of pasteurization per se upon the flavor of milk with particular emphasis on the feed flavors of milk.

PURPOSE OF THE EXPERIMENT

The purpose of the study was to determine the effect of different methods of pasteurizing on the flavor and the score of the milk. More specifically, the experiment was to include a study of the following points:

1. To determine the effect of holder pasteurization with aeration, without aeration, and with "hot short" pasteurization on the flavor and score of the processed milk as compared to the flavor and score of the raw milk from which it came.
2. To determine by statistical analysis whether the difference in the means of these scores was significant.
3. To observe the effect of holding the samples three days and scoring again and comparing the flavor and score after three days with the flavor and score after one day of holding.
4. To trace the mean score of the raw samples through a six months period.
5. To trace certain flavors through the pasteurizing processes.
6. To compute a percentage distribution of the flavors and score as found in raw, pasteurized unaerated, pasteurized aerated, and hot short pasteurized samples covering a six months period.

7. To compare the incidence of feed flavors in the first day's scoring with that of the third day's scoring on raw and on pasteurized samples.
8. To compare the scoring of the two judges and to plot the deviation of the rescoring from the first scoring.
9. To compare the scoring of the two judges and to plot the deviation in scoring of one from the other.

EXPERIMENTAL PROCEDURE

The samples of milk used in this study were taken in a large part from producer milk delivered daily to the College Creamery. The patrons' numbers were recorded and, thereafter, the samples were studied from these same patrons. Samples were collected in quart bottles and properly labeled with a key number. Each sample was divided into four lots which were processed as follows: Lot I, control, stored at 40°F; Lot II, one-half pint was put into a pint bottle and capped tightly. This sample was pasteurized at 143°F. for thirty minutes with the cap firmly in place so as to give no aeration during pasteurization and cooling; Lot III, one-half pint was put into a pint bottle and capped loosely. This sample was pasteurized at 143°F. for thirty minutes with the cap removed in order to allow for ample aeration during pasteurizing and cooling; Lot IV was "hot short" pasteurized at 160°F. for fifteen to eighteen seconds. All samples were stored at 40°F.

Holder pasteurization was accomplished in a specially built tank. The ten capped pint bottles, containing one-half pint of raw milk each, to be pasteurized without aeration, and the ten uncapped pint bottles, containing one-half pint of raw milk each, to be pasteurized were placed into an ordinary pint bottle crate which was placed into the tank of water. The water level in the tank was adjusted so that it would be above the level of the milk in the bottles. Live steam was used to raise the temperature of the heating medium. The crate was constantly shaken gently during heating so that the milk would be

heated uniformly and as quickly as possible without exposing any portion of the milk unduly long to the higher heat of the surrounding water. When the milk reached the temperature of 143°F., the crate was lifted out to prevent further heating; an alarm clock was set to designate the end of the one-half hour holding period; the water temperature in the tank was adjusted to 143°F.; and then the crate was replaced into the tank. The water temperature of the tank was kept slightly above 143.0°F. during the holding period. Gentle agitation was provided by shaking the crate. When the thirty minute holding period had expired cold water was turned into the tank from the bottom while the hot water ran out at the overflow. By this exchange of water the milk was rapidly cooled down to 55°F. with gentle, but constant agitation. The caps were then placed on the open bottles after which all the samples were put into the refrigerator until later studied.

High temperature short time pasteurization was accomplished in a specially constructed 7 mm. pyrex tube pasteurizer. The milk flowed by gravity through glass tubing coils surrounded by tempered water which heated the milk up to and maintained it at 160°F. for fifteen to eighteen seconds before passing through the ice water bath from which the milk was delivered at 55°F. Each sample was run separately through the whole set of coils. A one-half pint sample was caught at the cold delivery end, labeled, and stored for twenty-four hours in the refrigerator.

After storage for twenty-four hours, part of each sample was poured into a separate 100 ml. glass beaker. The beakers were numbered on the bottom according to the key numbers of the samples. The forty

beakers of raw, of pasteurized unaerated, of pasteurized aerated, and of "hot short" pasteurized samples were shuffled so that the judge had no knowledge of the sample being tasted. The judge then tasted the sample and gave it a numerical flavor score, varying from twelve to twenty-three --- depending upon the nature and extent of the criticism --- and indicated a criticism. This score and criticism were written on a pad and then the number on the bottom of the beaker was noted and recorded. After he had scored all the samples, the judge reshuffled the beakers and rescored the samples, recording his score and criticism as before but on a different paper. This second set of scores and criticisms was recorded as rescoring. Both sets of scores and crit- constituted the first day's readings. On the third day the samples were again scored, rescored, and the findings recorded on a different piece of paper exactly in the manner of the first day's judging. The recorded data from this set constituted the third day's readings. Both sets of data, first and third day readings, were then recorded in a data book in proper columns according to their key numbers.

RESULTS

A study of the flavor quality of the raw milk used in the experiment

The data obtained from flavor studies of the raw milk from ten producers over a six-month period are presented in Tables 1 and 2. A critical study of these samples by two judges showed that 40.5 and 45.1 per cent, respectively, were free of flavor criticism on the first day of storage. Of the off flavors noted, totaling, by the combined judgments, 56.74 per cent of the samples, feed flavors predominated with 23.29 per cent; high acid flavors were next with 8.71 per cent; and flat flavors were third with 6.81 per cent. Thirteen other off flavors were noted. These were present in a small percentage of the samples.

A study of these same samples after three days' storage at 40°F. showed a marked decrease in the number of samples without flavor criticism and with feed criticism. An increase was noted in the number of samples showing other off flavors, but the major increase was in the high acid, oxidized, and old stale flavors.

Each sample judged was given a numerical score in accordance with general milk scoring procedure. The percentage distribution of the samples of milk having specific scores is shown in Table 2. Here, it will be noted that 43.42 per cent of the samples on the first day merited a flavor score of 23. However, by the third day of storage, the number was reduced to 25.48 per cent of the samples. The mean score on the first day was 21.80 ± 1.78, whereas, on the third day it was

Table 1.

Percentage distribution of flavors in raw milk from ten producers over a six-month period when examined after the first and third days of storage at 40°F.

Flavor	Distribution of samples as noted by:					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
No criticism	40.54	26.74	45.16	22.91	43.26	24.45
Bitter	-----	-----	0.26	0.26	0.15	0.15
Cowy	1.15	-----	2.95	1.04	2.21	0.62
Feed	30.11	26.35	18.54	11.19	23.29	17.28
Fermented	-----	-----	0.26	0.52	0.15	0.31
Flat	10.03	7.75	4.56	2.60	6.81	4.67
Grassy	-----	-----	4.83	6.25	2.85	3.73
Heat	1.93	5.81	2.41	2.86	2.21	4.04
High acid	8.10	12.79	9.13	25.26	8.71	20.24
Metallic	0.38	1.16	0.26	0.78	0.31	0.95
Off, but unidentified	0.77	3.48	4.03	1.82	2.69	2.46
Old-stale	2.31	5.81	1.61	7.29	1.90	6.69
Oxidized	-----	0.38	2.68	7.03	1.58	4.36
Rancid	-----	1.93	0.53	4.42	0.31	3.42
Salty	3.86	5.81	1.88	2.08	2.69	3.58
Unclean	0.77	1.93	0.26	2.86	0.47	2.46
Weedy	-----	-----	0.53	0.78	0.31	0.46
Total per cent	99.95%	99.94%	99.88%	99.95%	99.90%	99.87%
Total number of samples	259	258	372	384	631	642

Table 2.

Percentage distribution of flavor scores of raw milk from ten producers over a six-month period when examined after the first and third days of storage at 40°F.

Score	Distribution of samples as noted by					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
23	40.15	26.61	45.83	24.07	43.42	25.48
22	23.48	19.78	22.22	15.58	22.75	17.62
21	25.75	36.33	16.66	17.84	20.51	21.28
20	3.78	6.11	6.11	12.18	5.12	9.61
19	2.65	2.51	3.33	6.23	3.04	4.14
18	4.16	5.75	5.55	21.81	4.96	14.90
17	-----	0.36	0.27	1.41	0.16	0.96
16	-----	-----	-----	0.84	-----	0.48
15	-----	2.51	-----	-----	-----	-----
Total	99.97	99.96	99.97	99.96	99.96	99.97
Total No. of samples	264	278	360	353	624	624
Mean	21.76	21.35	21.83	20.63	21.80	20.99
Standard deviation	1.7641	1.1113	1.4984	2.0164	1.78014	1.72461

Figure 1.

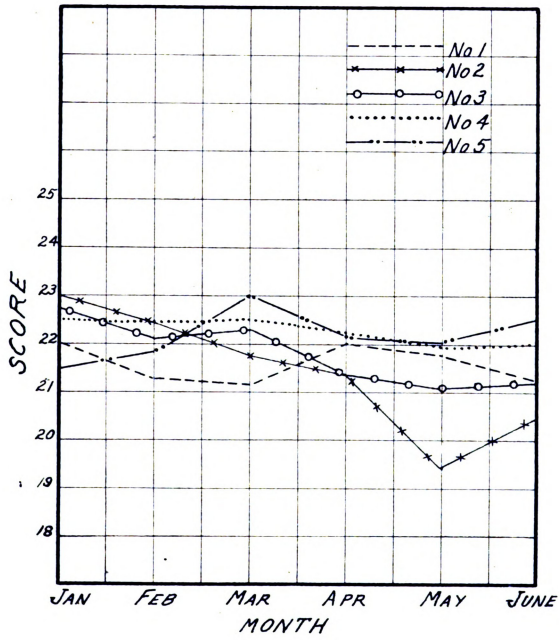

Figure 1. Average flavor score of mixed milk from producers one to five inclusive over a six-months period.

Figure 2.

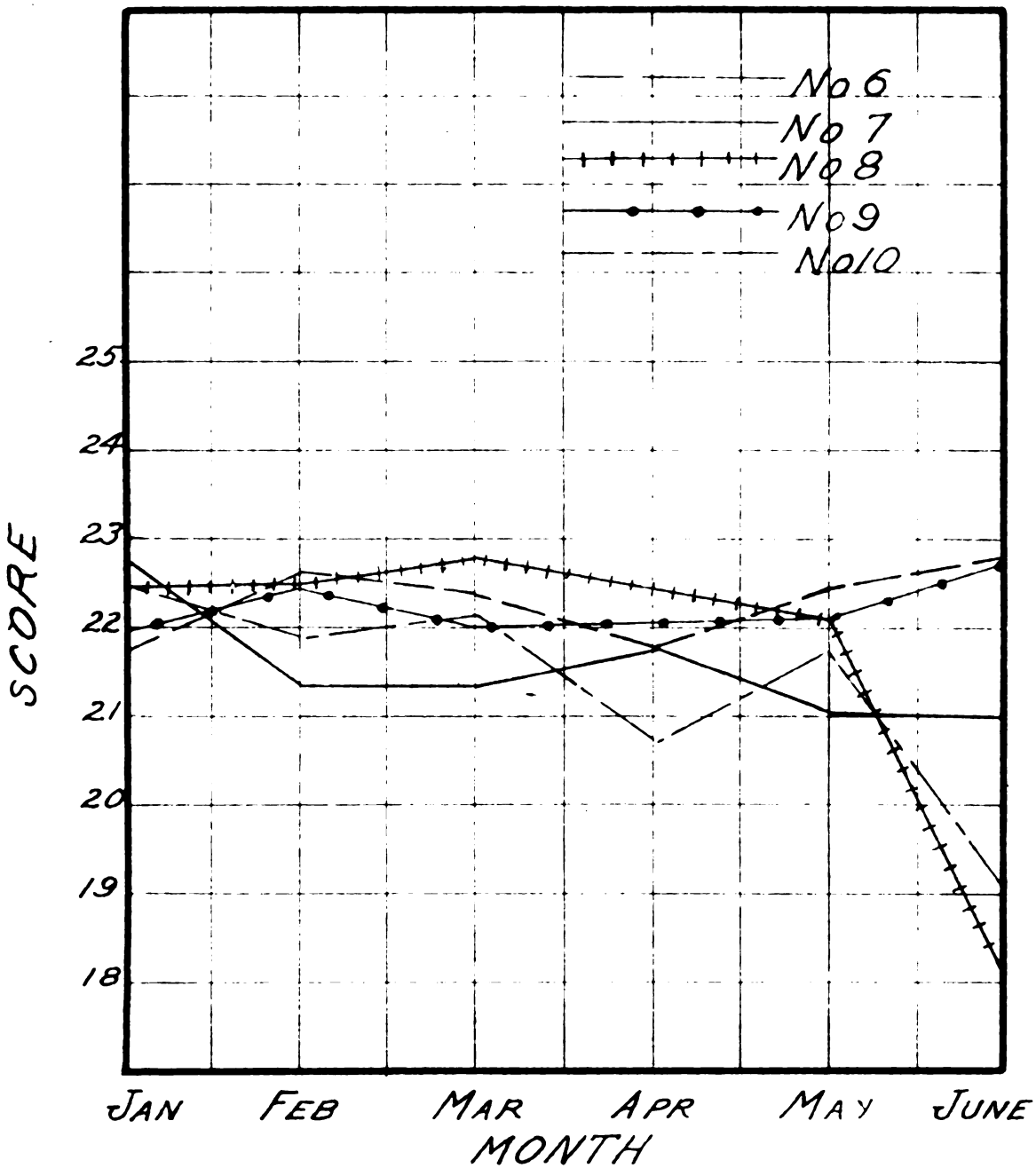

Figure 2. Average flavor score of mixed milk from producers numbers six to ten inclusive over a six-month period.

Figure 3.

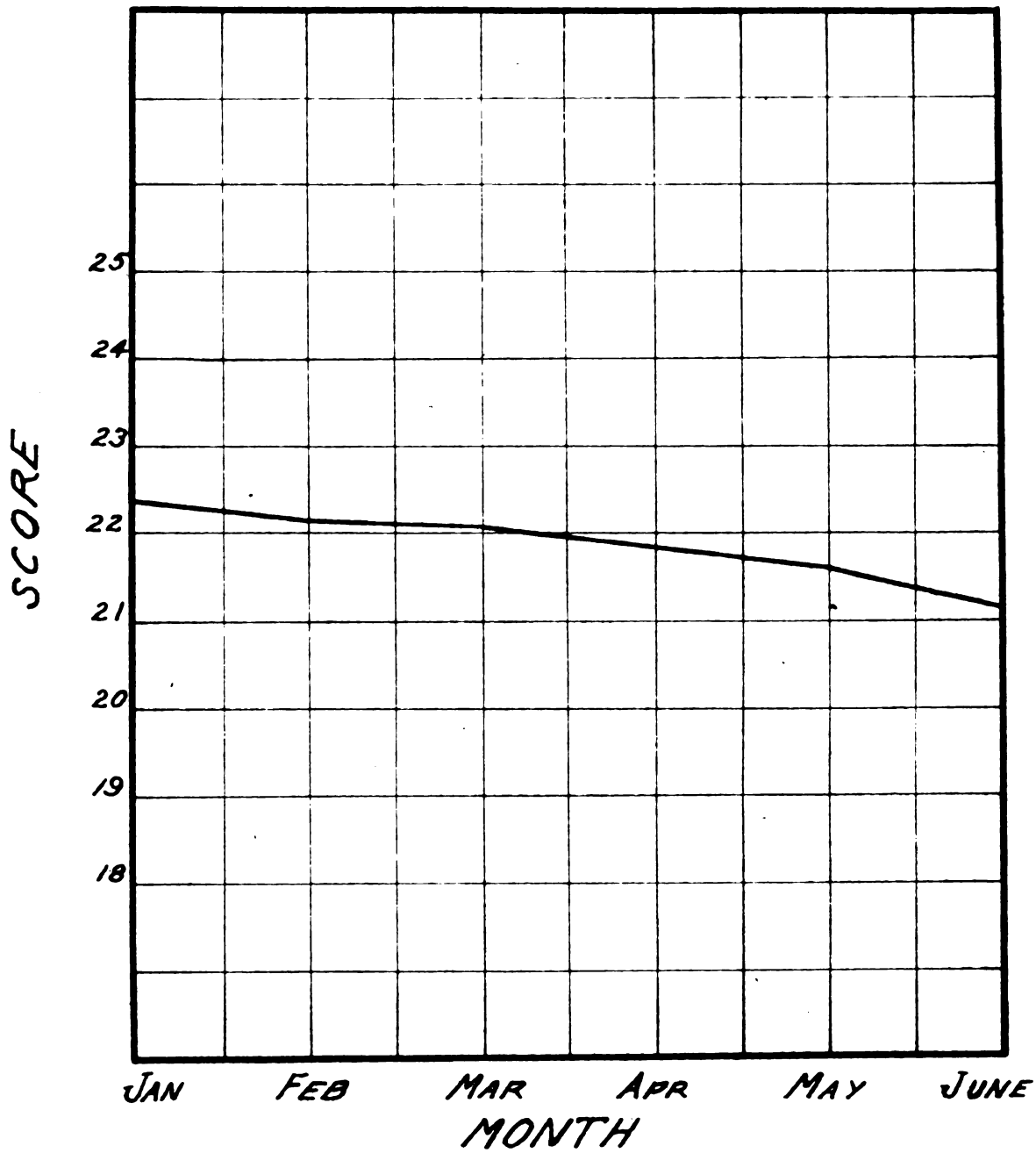

Figure 3. Mean flavor score of mixed milk from all ten producers over a six-months period.

20.99 ± 1.72. The decrease in score was found to be statistically significant.

The general quality of the individual samples of milk produced by months, as indicated by the flavor score, is shown graphically in Figures 1, 2, and 3. As the summer season approached there was a general lowering of the score due chiefly to the higher incidence of the feed flavors.

A study of the flavor quality of the milk holder pasteurized without aration.

The data obtained from flavor studies of the milk pasteurized without aeration from ten producers over a six-month period are presented in Tables 3 and 4. A critical study of these samples by two judges showed that 25.94 and 27.14 per cent, respectively, were free from ctiticism on the first day of storage. Of the off flavors noted, totaling by the combined judgments 73.37 per cent of the samples, heated flavors predominated with 33.33 per cent; feed flavors were next with 16.42 per cent; and cooked flavors third with 4.14 per cent. Fourteen other off flavors were noted. These were present in a small percentage of the samples.

A study of these same samples after three days storage at 40°F. showed a marked decrease in the number of samples without criticism. There was also a decrease in the number of samples having feed flavors and a decrease in the number of samples having heated flavors. An increase was noted in the number of samples having other off flavors, but the great increase was in the old-stale and oxidized flavors.

Low temperature holder pasteurization with aeration would seem to be responsible for a decrease in the incidence of the number of

samples having no criticism, feed, high acid, cowy, flat, and rancid flavors. From observations of the same tables, it appears that pasteurization without aeration is, likewise, responsible for an increase in the incidence of the number of samples having heat, mettalic, old-stale, and oxidized flavors.

A study of these same samples after three days storage at 40°F. showed a marked increase in oxidized and in old-stale flavors, and a decrease in cooked, heated, and feed flavors.

Each sample judged was given a numerical score in accordance with general milk scoring procedure. The percentage distribution of the samples of milk having specific scores is shown in Table 4. If will be noted that 27.27 per cent of the samples on the first day merited a flavor score of 23. However, by the third day of storage the number was reduced to 20.12 per cent of the samples. The mean score on the first day was 21.86 ± 1.014, whereas, on the third day the mean score was 21.43 ± 1.614. The decrease in score was found to be statistically significant. Combining the first and third day means of the raw milk samples, and combining the first and third day means of the pasteurized unaerated milk samples, it was found that the mean of the pasteurized milk samples was significantly higher than the mean of the raw milk samples.

Table 3.

Percentage distribution of flavors in milk from ten producers, pasteurized at 143°F. for 30 minutes without aeration when examined after the first and third days of storage at 40°F.

Flavor	Distribution of samples as noted by:					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
No criticism	25.94	23.79	27.14	17.41	26.63	19.93
Bitter	-----	-----	-----	0.26	-----	0.15
Cooked	2.25	2.41	5.54	3.95	4.14	3.34
Cowy	0.37	-----	1.38	1.84	0.95	1.11
Feed	21.05	12.09	13.19	7.38	16.42	9.25
Fermented	-----	-----	-----	0.52	-----	0.31
Flat	6.01	5.24	1.73	2.11	3.66	3.34
Grassy	-----	1.61	6.09	6.06	3.50	4.30
Heat	31.57	26.20	34.63	31.13	33.33	29.18
High acid	3.00	2.41	1.93	1.84	2.39	2.07
Metallic	0.75	2.41	-----	1.05	0.31	1.59
Off?, but unidentified	1.87	1.20	3.60	0.52	2.87	0.79
Old-stale	3.00	6.04	0.55	4.48	1.59	5.10
Oxidized	2.25	13.70	2.77	20.31	2.55	17.70
Rancid	-----	-----	-----	0.26	-----	0.15
Salty	1.50	2.41	0.83	0.26	1.11	1.11
Unclean	0.37	0.40	0.27	0.52	0.31	0.47
Weedy	-----	-----	0.27	-----	0.15	-----
Total per cent	99.93	99.91	100.11	99.90	99.91	99.89
Total number of samples	266	248	361	379	627	627

Table 4.

Percentage distribution of flavor scores on holder pasteurized unaerated milk from ten producers over a six-month period when examined after the first and third days of storage at 40°F.

Score	Distribution of samples as noted by					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
23	25.06	23.43	29.02	17.80	27.27	20.12
22	36.56	34.76	47.41	39.72	47.69	39.13
21	32.46	27.34	16.66	19.17	23.53	22.54
20	4.10	7.42	4.02	9.58	4.05	8.69
19	1.86	3.90	.86	7.94	1.29	6.28
18	-----	3.12	2.01	5.47	1.13	4.50
17	-----	-----	-----	0.27	-----	0.16
16	-----	-----	-----	-----	-----	-----
15	-----	-----	-----	-----	-----	-----
Total	99.98	99.97	99.98	99.95	99.96	100.46
Total no. of samples	268	256	348	365	616	621
Mean	21.76	21.57	21.93	21.32	21.86	21.43
Standard deviation	.7471	1.049	1.448	1.444	1.0145	1.614

A study of the flavor quality of the milk holder pasteurized with aeration

The data obtained from flavor studies of the milk, pasteurized with aeration, from ten producers over a six-month period are presented in Tables 5 and 6. A critical study of these samples by two judges showed that 21.84 and 27.50 per cent, respectively, were free from flavor criticism on the first day of storage. Of the off flavors noted, totaling by the combined judgments 75.04 per cent of the samples, heat flavors predominated with 30.32 per cent; other flavors were feed, 12.55 per cent; cooked, 6.43 per cent; flat, 5.81 per cent; old-stale, 4.74 per cent; and oxidized with 4.28 per cent. Twelve other off flavors were noted which were present only in a small percentage of the samples.

A study of these same samples after three days storage at 40°F. showed some decrease in the number of samples without criticism. There was also a decrease in the number of samples having cooked, heat, and feed flavors. An increase was noted in the number of samples having other off flavors, but the greatest increase was in old-stale and oxidized flavors.

Holder pasteurization with aeration appears, therefore, to be responsible for a decrease in the number of samples with no criticism when compared to raw milk and to milk pasteurized without aeration. Pasteurization with aeration seemed to be responsible for a decrease in the incidence of feed and high acid flavors over the percentage incidence of these flavors in raw milk and milk pasteurized without aeration. Furthermore, it was likely responsible for a decrease in the incidence of feed, high acid, cowy, flat, rancid, and off, but un-

identified, flavors when compared to the raw milk flavors.

A study of these same samples after three days storage at 40°F. showed a marked increase in oxidized and old-stale flavors when compared to raw milk; and an increase also of no criticism, cooked, flat, off, but unidentified, old-stale, and unclean flavors when compared to the flavors of milk pasteurized without aeration.

Each sample judged was given a numerical score in accordance with general milk scoring procedure. The percentage distribution of the samples of milk having specific scores is shown in Table 6. Twenty-nine and sixty-nine hundredths per cent of the samples on the first day merited a flavor score of 23. This number is considerably lower than the 43.42 per cent noted in the raw milk, but compared with 27.27 per cent of the milk pasteurized without aeration, is slightly higher. However, by the third day of storage the 29.29 per cent of uncriticised samples had dropped to 23.07 per cent. After three days of storage the raw milk having no criticism, or a 23 score, had dropped from 43.42 percent to 25.48 per cent, and the milk pasteurized without aeration had dropped from 27.27 per cent to 20.12 per cent. Hence, the milk pasteurized with aeration and having no criticism, decreasing from 29.69 per cent to 23.07 per cent in three days storage at 40°F., had fallen off less than either of the other two.

The mean score of the first day was 21.81 ± 1.113, whereas, on the third day the mean score was 21.34 ± 1.449. The decrease in the mean score after a three-day period was found to be statistically significant. Comparing the combined first and third day means of the raw milk samples with the combined first and third day means of the pasteurized aerated milk samples, it was found that the mean score of the pasteurized aerated milk samples was significantly higher than the mean score of the

Table 5.

Percentage distribution of flavors in milk pasteurized at 143°F. for 30 minutes with aeration when examined after the first and third days of storage at 40°F.

Flavor	Distribution of samples as noted by:					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
No criticism	21.84	23.22	27.50	18.13	24.96	20.24
Bitter	-----	-----	-----	-----	-----	-----
Cooked	6.82	3.37	6.11	4.80	6.43	4.20
Cowy	-----	-----	2.72	1.06	1.53	0.62
Feed	15.01	7.49	10.55	6.13	12.55	6.69
Fermented	-----	-----	0.83	0.26	0.45	0.15
Flat	6.82	10.48	5.00	4.00	5.81	6.54
Grassy	-----	-----	5.27	5.06	2.90	2.95
Heat	31.39	25.84	29.44	24.80	30.32	25.25
High acid	2.73	2.62	1.11	2.13	1.83	2.33
Metallic	0.34	1.87	-----	1.33	0.15	1.55
Off?, but unidentified	-----	1.49	2.77	1.06	1.53	1.24
Old, stale	8.19	7.11	1.94	7.20	4.74	7.16
Oxidized	3.41	12.73	5.00	21.06	4.28	17.60
Rancid	-----	-----	-----	-----	-----	-----
Salty	2.38	2.99	1.38	0.52	1.83	1.55
Unclean	1.02	0.74	-----	2.13	0.45	1.55
Weedy	-----	-----	0.27	0.26	0.15	0.15
Total per cent	99.95	99.95	99.89	99.94	99.91	99.75
Total no. of samples	293	267	360	375	653	642

Table 6.

Percentage distribution of flavor scores on holder pasteurized aerated milk from ten producers over a six-month period when examined after the first and third days of storage at 40°F.

Score	Distribution of samples as noted by:					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
23	26.00	26.13	32.36	20.65	29.69	23.07
22	29.67	26.89	39.52	35.32	35.38	31.60
21	32.23	28.40	21.48	16.46	26.00	21.73
20	7.69	9.46	4.50	8.68	5.84	9.03
19	2.93	6.81	0.53	11.67	1.53	9.19
18	1.46	2.28	1.59	7.78	1.53	5.35
17	-----	-----	-----	-----	-----	-----
16	-----	-----	-----	-----	-----	-----
15	-----	-----	-----	-----	-----	-----
Total	99.98	99.97	99.98	100.56	99.97	99.97
Total no. of samples	273	264	377	334	650	598
Mean	21.63	21.49	21.93	31.22	21.81	21.34
Standard deviation	1.255	1.322	1.188	1.597	1.113912	1.4494

Figure 4. Tank in which the milk was holder pasteurized (143°F.- 30 min.). A cover, not shown in the photograph, was placed on the tank during the holding period to aid in maintaining the desired temperature.

raw milk samples. However, there was no significant difference between the mean score of the pasteurized unaerated samples and the mean score of the pasteurized aerated samples.

A study of the flavor quality of the milk flash pasteurized at 160°F. for 15 seconds

The data obtained from flavor studies of the milk flash pasteurized at 160°F. for 15 seconds, from ten producers over a six-month period are presented in Tables 7 and 8. A critical study of these samples by two judges showed that 50.00 and 42.50 per cent, respectively, were free from flavor criticism on the first day of storage. This was greater than the per cent of uncriticized samples, 40.5 and 45.16; of the pasteurized unaerated milk samples, 25.94 and 27.14 per cent; or of the pasteurized aerated milk samples, 21.84 and 27.50, respectively.

Of the flavors noted, totaling, by combined judgments 54.46 per cent --- which is less than the 56.74 per cent noted in the raw samples, less than the 73.37 per cent in the pasteurized unaerated samples, and less than the 75.04 per cent in the pasteurized aerated samples --- feed flavors predominated with 16.08 per cent; heated flavors with 14.80 per cent; and flat flavors with 5.89 per cent. Fourteen other off flavors were noted which were present only in a small percentage of the samples. There was a larger percentage of samples with no criticism than was noted either in the raw samples or in the samples holder pasteurized aerated and unaerated. Also, there was a lower percentage of feedy samples than was noted in the raw samples. About the same percentage of feedy samples was noted as in the samples of milk pasteurized without aeration. However, a slightly higher percentage of feedy samples was noted in the flash pasteurized samples than was noted in the

milk pasteurized with aeration.

A study of these same flash pasteurized milk samples after three days of storage at 40°F. showed a decrease in the number of samples without flavor criticism. The percentage dropped from 45.54 per cent to 31.73 per cent. This decrease was less than that encountered in the raw milk samples, but more than observed in the pasteurized aerated and in the unaerated milk. There was also a decrease in the per cent of samples with feed, cowy, and heated flavor, but similar to that found in the raw milk in the pasteurized aerated and in the unaerated milk samples covering the same storage period. An increase was noted in the number of samples showing other off flavors, but the major increase was in the oxidized and old-stale flavored samples. The increase of old-stale samples was greater for the flash pasteurized milk samples than for any other group of samples. The increase in the oxidized flavored samples was less than that in the pasteurized aerated or in the pasteurized unaerated milk groups, but greater than in the raw milk group.

Each sample judged was given a numerical score in accordance with general milk scoring procedure. The percentage distribution of the samples of milk having specific scores is shown in Table 8. Here, it will be noted that 47.07 per cent of the samples on the first day merited a flavor score of 23. This percentage is much greater than the percentage of the raw samples, pasteurized unaerated samples, or pasteurized aerated samples that received a score of 23. However, by the third day of storage the per cent receiving a score of 23 decreased to 33.33 per cent. Here again, it will be noted that this is a much greater percentage to receive a score of 23 than either the raw milk,

pasteurized unaerated, or pasteurized aerated milk samples. The mean of the score for the first day of storage was 22.16 ± 1.083, whereas, on the third day it was 21.57 ± 1.370. The decrease in score was found to be significant. The mean of the first day flash pasteurized samples was found to be significantly higher than the first day mean of the raw or holder pasteurized milk samples. There was, however, no significant difference between the means of the scores of the samples of the three groups of pasteurized milk when stored three days. After storage for three days, the mean score of any group of pasteurized milk was significantly higher than that of the raw milk samples similarly stored. Combining first and third day scores, it was found that the mean of the flash pasteurized milk samples was significantly higher than those of pasteurized aerated, or pasteurized unaerated, or of raw milk. It is also noted that after storage of the milk for three days, the standard deviations decreased from 1.742 for the raw; to 1.614 for the pasteurized unaerated; to 1.449 for the pasteurized aerated, and to 1.370 for the flash pasteurized milk. These decreases indicate that holder pasteurization results in a milk capable of being scored with less deviation or scattering of the scores than raw milk, and that flash pasteurization is even more effective in this respect than holder pasteurization.

Table 7.

Percentage distribution of flavors in milk, pasteurized at 160°F. for 15 seconds when examined after the first and third days of storage at 40°F.

Flavor	Distribution of samples as noted by:					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
No criticism	50.00	31.03	42.50	32.29	45.54	31.73
Bitter	-----	-----	-----	-----	-----	-----
Cooked	-----	-----	-----	-----	-----	-----
Cowy	0.76	-----	1.90	0.77	1.43	0.46
Feed	17.93	18.00	14.71	7.49	16.08	11.76
Fermented	-----	-----	0.54	0.77	0.31	0.46
Flat	9.16	7.27	3.54	3.61	5.89	5.10
Grassy	0.76	-----	4.90	5.68	3.18	3.40
Heat	10.30	13.40	17.98	11.36	14.80	12.22
High acid	1.52	1.14	2.70	2.84	2.22	2.16
Metallic	-----	1.14	0.27	1.29	0.15	1.23
Off?, but unidentified	1.14	3.06	4.08	1.55	2.86	2.16
Old-stale	4.20	9.19	1.36	9.82	2.54	9.59
Oxidized	0.38	9.96	3.81	17.82	2.38	14.70
Rancid	-----	0.38	0.54	1.03	0.31	0.77
Salty	2.29	4.59	0.81	2.32	1.43	3.25
Unclean	1.52	0.38	-----	0.77	0.63	0.61
Weedy	-----	-----	0.27	0.51	0.15	0.30
Total per cent	99.96	99.54	99.92	99.92	99.90	99.90
Total no of samples	262	261	367	387	628	646

Table 8.

Percentage distribution of flavor scores in flash pasteurized milk (160°F. - 15 sec.) when examined after the first and third day of storage at 40°F.

Score	Distribution of samples as noted by:					
	Judge I		Judge II		Combined judgments	
	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
23	49.62	31.78	45.17	34.45	47.07	33.33
22	24.62	20.15	32.95	23.52	29.38	22.11
21	22.34	35.27	13.35	17.64	17.20	25.04
20	2.27	9.30	4.54	12.60	3.57	11.21
19	0.37	2.32	2.27	7.56	1.47	5.36
18	0.75	1.16	1.70	3.36	1.29	2.43
17	-----	-----	-----	-----	-----	-----
16	-----	-----	-----	0.56	-----	0.32
15	-----	-----	-----	0.28	-----	0.16
Total	99.97	99.98	99.98	99.97	99.94	99.96
Total no. of samples	264	258	352	357	616	615
Mean	22.18	21.66	22.14	21.50	22.16	21.57
Standard deviation	1.0866	1.2021	.4483	1.3307	1.083420	1.37047

Figure 5. Apparatus used for flash pasteurization (160°F. - 15 sec.) of the milk.

Flavors tending to increase or decrease as a result of pasteurization

A study of the data showed that certain flavors tended to increase as a result of pasteurization. These data are presented in Table 9. Pasteurization without aeration apparently accounted for an increase of 31.07 per cent in the heated flavor and a 4.14 per cent increase in the cooked flavor over the control samples. Also, pasteurization with aeration was responsible for an increase of 28.06 per cent in the heated flavor and a 6.43 per cent increase in the cooked flavor. On the other hand, flash pasteurization was responsible for an increase of only 12.54 per cent of the heated flavor with no increase of the cooked flavor. Furthermore, flash pasteurization was responsible for a smaller increase, 0.80 per cent, in the oxidized flavor than either of the holder methods of pasteurization. A study of the data obtained after storage for three days at 40°F. showed similar increases throughout, but it was noted that the increase in oxidized flavors for the samples which had been flash pasteurized was approximately three per cent less than the samples which had been pasteurized by the holder methods.

A study of the data showed that certain flavors tended to decrease as a result of pasteurization. These data are also included in Table 10. Whereas, the number of samples which had been holder pasteurized decreased in the percentage showing no criticism, the number of flash pasteurized samples increased in the percentage showing no criticism. The samples of milk which had been pasteurized with aeration showed a greater per cent decrease in feed flavors by three per cent than either

Table 9.

Flavors tending to increase as a result of pasteurization.

Flavor	Raw milk	Percentage distribution in: Holder pasteurized milk (143°F. - 30 min.) Unaerated		Aerated		Flash pasteurized milk (160°F.-15 sec.)	
	Incidence	Incidence	Increase	Incidence	Increase	Incidence	Increase
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
			First day judgments				
No criticism	43.26	26.63	16.63*	24.96	18.30*	45.54	2.28
Cooked	0.00	4.14	4.14	6.43	6.43	0.00	0.00
Grassy	2.85	3.50	0.65	2.90	0.05	3.18	0.33
Heat, slight	2.26	33.33	31.07	30.32	28.06	14.80	12.54
Oxidized	1.58	2.55	.97	4.28	2.70	2.38	0.80
			Third day judgments				
No criticism	24.45	19.93	4.52*	20.24	4.21*	31.73	7.28
Cooked	0.00	3.34	3.34	4.20	4.20	0.00	0.00
Flat	4.67	3.34	1.33*	6.54	1.87	5.10	.43
Grassy	3.73	4.30	0.57	2.95	0.85*	3.40	.33*
Heat	4.04	29.18	25.14	25.25	21.21	12.22	8.19
Metallic	0.95	1.59	0.64	1.55	0.60	1.23	0.28
Old-stale	6.69	5.10	1.59*	7.16	0.47	9.59	2.90
Oxidized	4.36	17.70	13.34	17.60	13.24	14.70	10.34

*Decrease

Table 10.

Flavors tending to decrease as a result of pasteurization.

Flavor	Raw milk	Percentage distribution in: Holder pasteurized milk (143°F. - 30 min.) Unaerated		Aerated		Flash pasteurized milk (160°F.-15 sec.)	
	Incidence	Incidence	Increase	Incidence	Increase	Incidence	Increase
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
			First day judgments				
No criticism	43.26	26.63	16.63	24.96	18.30	45.54 *	2.28*
Cowy	2.21	.95	1.26	1.53	0.68	1.43	0.78
Feed	23.29	16.42	6.87	12.55	10.74	16.08	7.21
Flat	6.81	3.66	3.16	5.81	1.00	5.89	0.92
High acid	8.71	2.39	6.32	1.83	6.88	2.22	6.49
Rancid	0.31	0.00	0.31	0.00	0.31	0.31	0.00
Salty	2.69	1.11	1.58	1.83	0.86	1.43	1.26
Weedy	0.31	0.15	0.16	.15	0.16	0.15	0.16
			Third day judgments				
No criticism	24.45	19.93	4.52	20.24	4.21	31.73 *	7.28*
Cowy	0.62	1.11	0.49*	0.62	0.00	0.46	0.16
Feed	17.28	9.25	8.03	6.69	10.59	11.76	5.52
Flat	4.67	3.34	1.33	6.54	1.87	5.10	0.53*
Grassy	3.73	4.30	0.57*	2.95	0.78	3.40	0.33
High acid	20.24	2.07	18.17	2.33	17.91	2.16	18.08
Off?, but unidentified	2.46	0.79	1.67	1.24	1.22	2.16	0.30
Rancid	3.42	0.15	3.27	0.00	3.42	0.77	2.65
Salty	3.58	1.11	2.47	1.55	2.03	3.25	0.33
Unclean	2.46	0.47	1.99	1.55	0.91	0.61	1.85
Weedy	0.46	0.00	0.46	0.15	0.51	0.30	0.16

*Increase

of the samples pasteurized without aeration or the samples which had been flash pasteurized. Observations of the data obtained after these same samples were stored for three days at 40°F. showed virtually the same decreases with reference to the percentage of samples without criticism and samples with feed flavor, as were noted after one day storage.

Reliability of flavor judgments

As stated in the procedure, two experienced judges scored all the samples "blind" and after reshuffling the samples, recorded them, not knowing the previous score or criticism at the time of the second judgment in an effort to determine (1) the reliability of a single flavor judgment, and (2) the closeness of scoring by the two judges.

The data obtained are summarized and presented in Tables 11 and 12, and in Figure 6. Judge I rescored 41.0 per cent of the samples identically with the first score (Figure 6.). Assuming that the first day's first scoring was correct, Judge I deviated from that score on rescoring as shown in Table 11 by ±1 point in 48.00 per cent of the 1162 samples involved; by ±2 points in 16 per cent of the judgments. The tendency of this judge was to be more critical and to underscore the samples on second scoring. However, it must be borne in mind that the temperature rose between second and first judgments; hence, some off flavors might and might not be detected on the second judgment.

Judge II rescored 50.00 per cent of the samples identically with the first score (Figure 6.). Judge II deviated from his first score on rescoring as shown in Table 12 by ±1 points in 31.00 per cent of the 1546 samples involved; by ±2 points in seven per cent of the samples. The tendency of this judge also was to be more critical and to underscore

the samples on rescoring.

A comparison of the third day scores and judgments with those of the rescoring judgments reveals that Judge I had a tendency to rescore the samples higher and with a greater range. The per cent of samples which were rescored with a deviation of ±1 was 34.00 per cent which was less than the first day's rescoring of 48.00 per cent. The per cent of samples which were rescored with a deviation of ±2 was 16.00 per cent, the same as on rescoring the first day samples. The deviations by ±3 points rose from less than one-half of one per cent in the first day rescoring judgments to over one per cent in the third day scoring judgments. The flavors which predominated in the milk after three days of storage were such that made accurate rescoring difficult. Such flavors were oxidized, old-stale, and high acid, all of which had varying intensities.

Comparing the third day scores and judgments with the rescoring data reveals that Judge II had a tendency to rescore the samples higher and with a still greater range of score than Judge I. The per cent of samples which were rescored with a deviation of ± was 25.00 per cent, which was less than the first day's scoring deviation of 33 per cent. The per cent of samples which were rescored with a deviation of ±2 was 12.0 per cent which was higher than that of the first day's rescoring of 8 per cent. The deviations by ±3 points rose from less than two to three per cent in the third day rescoring judgments.

Assuming that the first day score of Judge I was correct, the deviations in score of Judge II were plotted against it and the results shown on Figure 7. The results indicate a normal curve with slight negative ketosis. The curve shows that the two judges agreed exactly on 58 per cent of the judgments. The deviations of Judge II's score from

the score of Judge I was more than ±3 points in a greater number of samples than one would expect in a normal distribution, indicating that Judge II went to extremes more often in judgments than Judge I.

Table 11.

Deviation of the second from the first flavor score when the samples were rescored. Judge I.

Deviation	Percentage distribution of samples of							
	Raw milk		Holder pasteurized milk (143°F. - 30 min.)				Flash pasteurized (160°F. - 15 sec.)	
			Unaerated		Aerated			
	1st day	3rd day	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
+5								
+4								
+3		0.7		0.7	1.3	2.8		0.6
+2	8.0	13.8	8.7	7.4	8.8	8.2	8.5	12.3
+1	20.8	16.7	16.8	25.9	19.7	18.5	15.7	17.5
0	42.0	37.2	43.2	34.8	38.7	40.7	44.0	49.3
-1	16.7	19.7	22.2	24.4	25.5	22.0	20.0	13.6
-2	10.7	8.0	7.4	6.6	4.7	7.0	10.5	5.8
-3	1.3	3.6	1.3		0.0			0.6
-4					0.6			
-5								

Table 12.

Deviation of the second from the first flavor score when the samples were rescored. Judge II.

Deviation	Percentage distribution of samples of							
	Raw milk		Holder pasteurized milk (143°F. - 30 min.)				Flash pasteurized (160°F. - 15 sec)	
			Unaerated		Aerated			
	1st day	3rd day	1st day	3rd day	1st day	3rd day	1st day	3rd day
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
+5		0.9						
+4	1.4	1.4	0.5			1.0	0.5	1.0
+3	1.4	0.9	0.5	0.5		2.6	0.0	2.0
+2	1.9	3.4	5.6	1.0	6.9	4.2	3.5	7.6
+1	11.4	12.4	14.2	18.5	19.7	20.0	16.9	18.7
0	61.0	46.0	55.6	52.0	45.4	43.0	56.9	44.6
-1	12.4	16.0	19.3	20.0	23.5	21.2	17.4	16.2
-2	4.4	13.9	3.0	5.2	3.2	5.8	2.5	7.1
-3	2.9	0.9	0.0	1.5	0.5	0.5	1.5	2.0
-4	1.4	1.9	1.0		0.5	1.0	1.0	0.5
-5	0.9	0.9						

Figure 6.

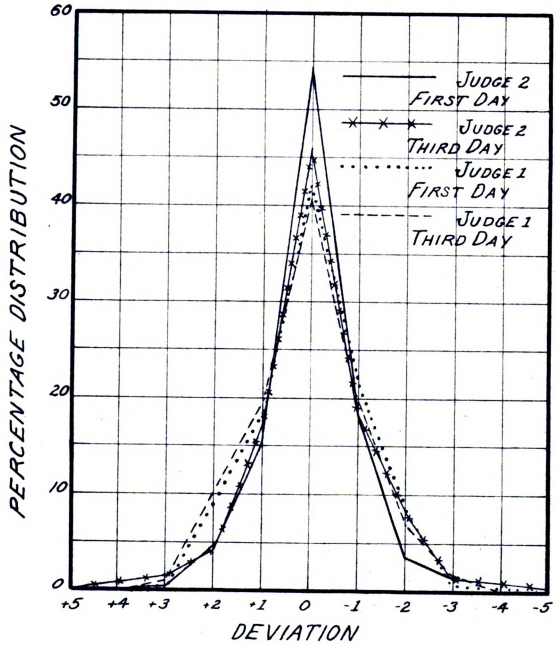

Figure 6. Distribution curves of the deviation between the first and second scores of the judges.

Figure 7.

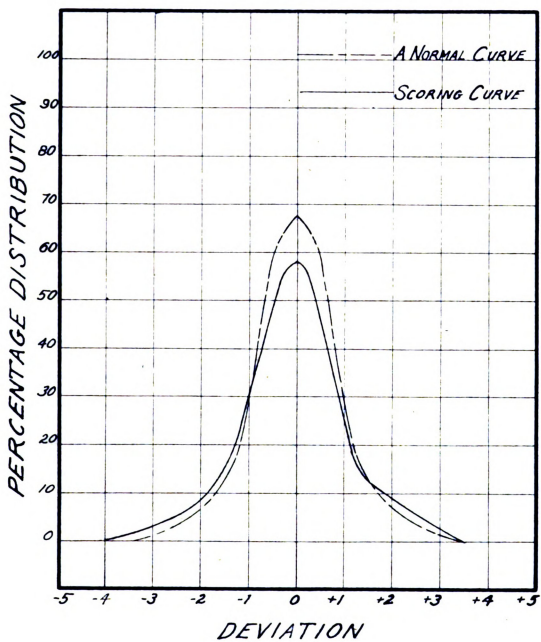

Figure 7. A comparison of the distribution curve of the deviation between the judges scores on all samples of milk with a normal distribution curve.

The development of oxidized flavors in the milk during the period of the study.

Although oxidized flavor was noted from time to time in many of the samples of milk regardless of treatment, the data obtained from holder pasteurized unaerated milk only are presented graphically in Figure 8. Included also are data relative to the incidence of feed flavor over the same period. Strikingly, as the incidence of feed flavor increased markedly, there was a drastic break in the incidence of the oxidized flavors. These trends are well illustrated in Figure 8. A check-up on the producers from whom the milk for this study was obtained revealed the fact that by the third week of April the majority of the producers had turned the cows to pasture. This observation on the decreased incidence of oxidized flavor is common to general commercial experience, namely, the lower incidence of oxidized flavors occurring in late spring or early summer. The marked increase in the incidence of feedy flavors which occurred May first was due to the great increase in the prevalence of grassy flavors rather than silage feedy flavors.

Figure 8.

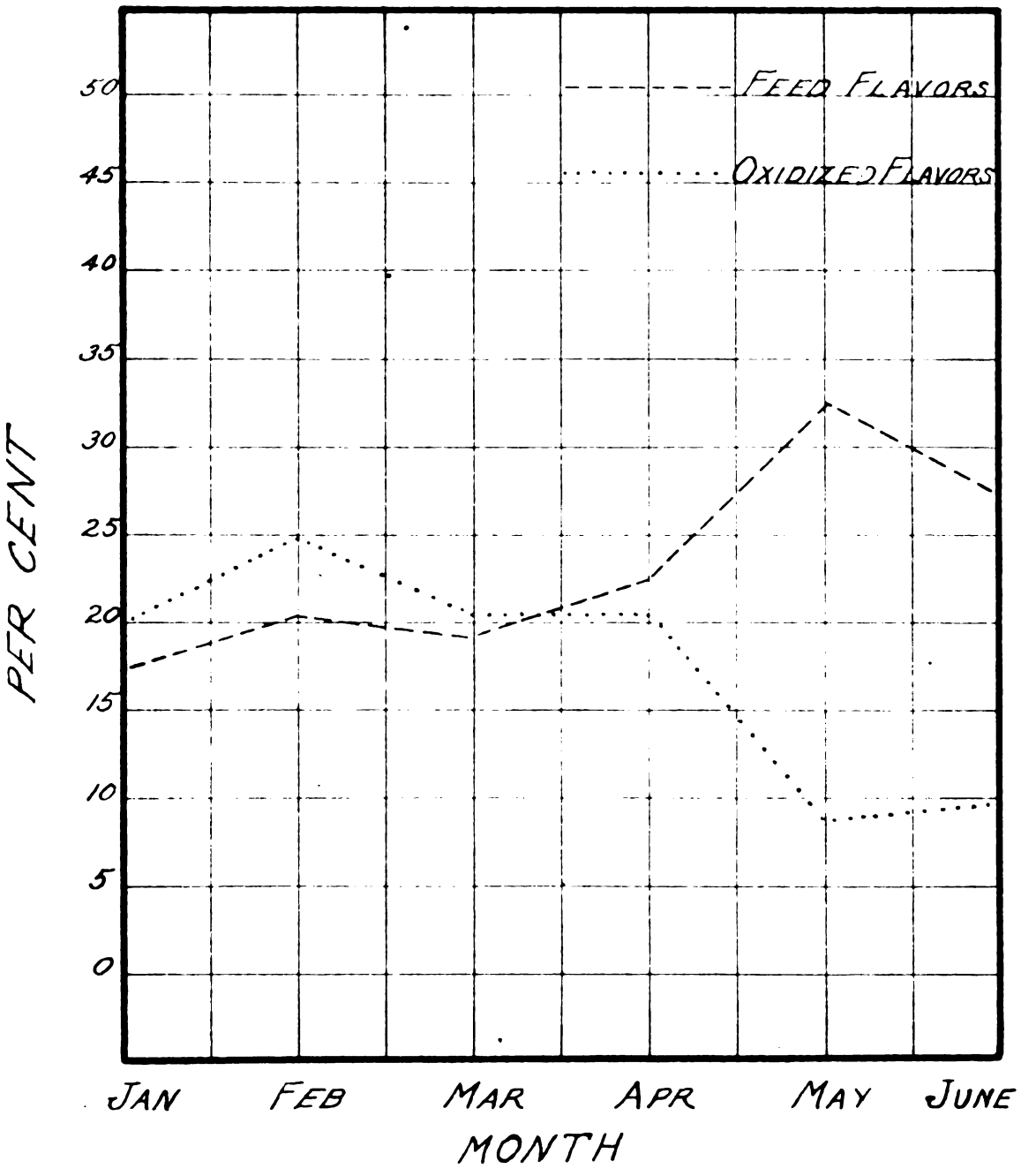

Figure 8. The percentage of oxidized flavored samples found in unaerated holder pasteurized milk, over a six-month period and the percentage of feed flavored samples found in the raw milk over the same period, illustrating the relationship between the two flavors.

DISCUSSION

An analysis of all the data gathered from the flavor scores and criticisms revealed that pasteurization improved the flavors and score of milk. This finding is in agreement with the findings of Tracy and Ruehe (1931) who found that pasteurization by the holding method improved milk flavor to some extent.

Other workers, Marquardt and Dahlberg (1934), Sharp, Trout and Guthrie (1936), Dahle and Palmer (1937) found more oxidized flavors in holder pasteurized milk than they found in the raw milk. The results of this study agree with the findings of these workers.

Flash pasteurization was found to be superior to holder pasteurization in flavor and score improvement. Quinn and Burgwald (1933) concluded that high temperature short time pasteurization imparted less "cooked" flavor to the milk than did the holder method. It is interesting to note that the samples of milk which were flash pasteurized in this study had no "cooked" flavor criticisms, while those samples that were holder pasteurized had four to six per cent "cooked" flavor.

Holding the milk in storage at 40°F. decreased the score of the milk and produced a smaller number of samples without criticism. Trout (1937) found that holding raw milk for three days in storage at 40°F. decreased the number of samples without criticism from 41.1 per cent to 28.5 per cent. Storage of holder pasteurized milk under the same conditions reduced the number of samples without criticism from 13.3 per cent to 12.0 per cent. The results of this study show that storage of raw milk at 40°F. for three days reduced the number of

samples without criticism from 43.26 per cent to 24.45 per cent, but storage of holder pasteurized milk under the same conditions reduced the number of samples without criticism from 25.78 per cent to 20.08 per cent. The percentage decrease for raw and holder pasteurized samples in this study is greater than that found by Trout in 1937. Possibly the difference may be accounted for in that the judges in this study found more off flavors than did the judges in Trout's study.

The samples without criticism of the flash pasteurized milk in this study, stored under the same conditions, decreased from 45.54 per cent to 31.73 per cent. The percentage decrease in the samples without criticism was greater for flash pasteurized milk than for holder pasteurized milk. However, after the first day's storage period, there was 20.0 per cent more samples without criticism in the flash pasteurized milk than in the holder pasteurized milk, and after three days' storage period there was 10.0 per cent more samples without criticism in the flash pasteurized milk than in the holder pasteurized milk. A higher per cent of old-stale flavors developed in the flash pasteurized milk during the storage period than in the holder pasteurized milk.

Some flavors tended to increase in percentage incidence as a result of pasteurization, namely: grassy, heat, cooked, oxidized, metallic, and old-stale. This finding coincides with the results of the work of Tracy and Ruehe (1931), Marquardt and Dahlberg (1934), Sharp, Trout and Guthrie, (1936), Dahle and Palmer (1937) with reference to oxidized flavor and with the work of Trout (1937) with reference to cooked, heat, metallic, and stale flavors. No references in the literature on the the increase of grassy flavors in pasteurized milk were found. A possible explanation is that grassy flavors may be somewhat similar to a com-

bination of other flavors, possibly heat and old-stale, for example. This possibility may account, in part, for the lack of data in the literature on the effect of pasteurization on grassy flavors.

Some flavors tended to decrease as a result of pasteurization, namely: no criticism, feed, flat, high acid, salty, cowy, rancid, weedy, and off but unidentified flavors. This finding coincides with the findings of Riddet and Valentine (1923), Tracy and Ruehe (1931) Marquardt and Dahlberg (1934), the New York State Experiment Station (1936), and Trout (1937). The holder method of pasteurization with aeration was responsible for a greater decrease in feed flavors by 4.0 per cent than either holder pasteurization without aeration or flash pasteurization --- both of which resulted in similar percentages of feed flavors at the end of one day's storage. This indicates that aeration during heating is a factor in removal of feed flavors from milk, which agrees with the findings of Weaver (1935), and McCandlish and Leitch (1932).

The data from this study showed that there was less scattering of score about the mean score of the milk samples in pasteurized milk than in the raw milk. A possible explanation is that the milk containing those off flavors, which are reduced in intensity as a result of heat treatment, tends to be raised toward the normal or mean score of all the samples. Marquardt and Dahlberg (1934) and Tracy and Ruehe (1931) showed that pasteurization tended to reduce the intensity of certain off flavors.

The mean score of all the raw milk samples decreased from January to June. Three possible explanations are proposed to account for this change. (1) The judges became more critical of the milk as

the study progressed. (2) Spring work made less time available for caring for the milk. (3) Permitting the cows access to pasture resulted in more fresh feeds and more volatile flavors being present. The data show that the per cent of oxidized flavors and the per cent of feed flavors in the milk remained about constant until the first of April.

At this time there appeared a greater percentage of feed flavors and a smaller percentage of oxidized flavors in the milk. The explanation may be that as the cows were turned to pasture and were able to obtain green feeds, they absorbed larger amounts of anticxidants present in green feeds and pasture grass. Hence, the percentage of oxidized flavors decreased as the percentage of feed flavors increased. This explanation is in agreement with common commercial experience that during late spring and summer months, the incidence of oxidized flavors diminishes.

The two judges agreed perfectly on the score of the milk on 58.0 per cent of the samples. Judge I had a relatively narrow range of scoring the milk and recorded approximately 41.0 per cent of the samples with no deviation in score. Judge II had a wider range of scoring than did Judge I, yet he repeated his first score upon rescoring approximately 50 per cent of the samples. These findings are of interest when compared to the findings of Trout and Sharp (1937) who found that eight judges scoring and rescoring 244 samples of milk were only able to repeat their first score on rescoring on 30 per cent of the samples. Individual judges varied considerably in their ability to rescore samples without deviation, the percentage of identically scored samples being 37.1, 37.1, 22.8, 14.3, 37.1, 42.9 for each of six judges.

SUMMARY

Approximately 1162 samples of milk were scored and rescored by two judges over a six month period. These samples of milk studied were subjected to holder pasteurization (143°F. - 30 min.) with and without aeration and to flash pasteurization (160°F. - 15 sec.). The data secured indicated that pasteurization, whether holder (143°F. - 30 min.) or flash (160°F. - 15 sec.), improved the flavor and score of the milk. However, flash pasteurization was superior to holder pasteurization with or without aeration.

No significant difference was found between holder pasteurization with aeration and similar pasteurization without aeration on the flavor and score of the milk, considering the distribution of flavors and scores as a whole.

Storing the milk for three days at 40°F. resulted in a significant decrease in the score. Raw milk scores decreased two points as a result of storage, whereas, all pasteurized milk scores decreased but one-half of one point.

Pasteurization increased the incidence of grassy, heat, oxidized, cooked, old-stale and metallic flavors and decreased the incidence of feed, acid, flat, salty, cowy, rancid, weedy, unclean, and off, but unidentified flavors.

Storage of the milk, both raw and pasteurized, at 40°F. for three days increased the percentage incidence of high acid, old-stale, oxidized, unclean, and rancid flavors, whereas, storage for three days decreased the percentage incidence of feed, cowy, flat, slight heat,

cooked, and off, but unidentified flavors.

Pasteurization increased the mean of the scores of the milk as follows:

Heat treatment	Score after storage 1st day	3rd day
Raw (control	21.80	20.99
Holder pasteurized (143°F. - 30 min.)		
Without aeration	21.86	20.43
With aeration	21.81	21.34
Flash pasteurized (160°F. - 15 sec.)	22.16	21.56

A greater scattering of the score of the raw milk was noted than of the pasteurized milk. Less scattering was noted in the holder pasteurized samples with aeration than without aeration; and even less was noted when the samples were flash pasteurized. Flash pasteurization was found to be superior to the two holder methods of pasteurization in maintaining a higher and more uniform score.

The mean score of the raw milk of all patrons decreased steadily from January through June. A gradual increase in the incidence of feed flavors was found in the raw samples from January, with 17.5 per cent, February, 20.8, March 19.3, April, 22.4, to May when they increased to 32.5 per cent after which they receded to 27.5 per cent for June. During the same period of time there was noted a rather constant incidence of oxidized flavors in the samples of the pasteurized unaerated milk from January with 20.0 per cent, February, 25.0, March 20.7, April, 20.7, until May when the per cent decreased to 10.0. As the incidence of feed flavors increased a very similar decrease in the occurrence of the oxidized flavors was noted.

The two judges differed slightly in rescoring ability. One judge rescored 41 per cent of the samples identically with the first score,

whereas, the other judge rescored 50 per cent of the samples identically with the first score. The deviation on rescoring approximated closely a normal curve. When one judge's score was plotted against the other judge's score, the results showed a normal curve with slight negative kurtosis. Both judges, scoring independently, scored fifty-eight per cent of the total samples with the same score.

PART II

PART II

PURPOSE OF THE EXPERIMENT

The purpose of this section of the study was to determine how much silage, either alfalfa or corn, could be fed to a cow one hour before milking without producing an objectionable flavor in the pasteurized milk. More specifically this study was to determine:

1. How much silage could be fed to a cow per pound of milk produced without decreasing the flavor score of the milk below twenty-two in:
    (a) Raw milk
    (b) Pasteurized unaerated milk
    (c) Pasteurized aerated milk
    (d) Vacuum pasteurized milk
    (e) Forced aerated milk.
2. The effect of these different methods of pasteurizing the milk on the score and criticisms after three days of storage.
3. Which of the above methods of pasteurizing was superior in feed flavor removal.
4. Which of the above methods of pasteurizing was likely to produce additional off flavors.
5. The relative volatility of the substance that caused the characteristic feed flavors resulting from silage feeding.

EXPERIMENTAL PROCEDURE

A large Holstein cow was selected for the feeding experiments because she was free from mastitis and Bang's disease, gave about twenty pounds of milk at each milking, and, at the start of the experiment, had been in lactation two months. One hour before milking she was given silage in amounts varying from one pound to thirty-five pounds. The cow was milked by machine. The milk, immediately weighed, poured into clean cold bottles and capped, was cooled to 55°F. by cold circulating water.

Since the time of feeding was kept constant, the intensity of the silage flavor in the milk was calculated by dividing the weight of the milk given at that milking into the pounds of silage fed to the cow.

A one-half pint sample of the milk was then secured as a control. The remainder of the milk was processed as follows:

1. One pint of the raw silage milk was placed in a quart bottle and the cap firmly seated. A similar sample of the raw silage milk was placed in another quart bottle uncapped. These two samples were holder pasteurized at 143°F. for 30 minutes in the same apparatus previously described on page 17 of this study. This process provided samples of pasteurized aerated and unaerated silage milk.

2. One quart of the fresh raw silage milk was placed into a four-liter erlenmeyer flask, heated to 143°F, and held for 30 minutes --- during which time the milk was gently agitated. A partial vacuum was maintained in the flask so that maximum removal of the flavors could

be effected, yet boiling of the milk did not occur. Following the pasteurization exposure, the milk was cooled in the flask after which a sample was secured for later study. This procedure provided the vacuum pasteurized silage milk.

3. Another portion of the raw silage milk was holder pasteurized, but air was bubbled through during the holding period. This was accomplished as follows: A glass tube was passed through the top of the rubber stopper of the erlenmeyer flask and extended down to the bottom through the quart of silage milk. The stopcock on the "vacuum control valve" was closed and operations started. The vacuum pump, creating a partial vacuum above the milk of the erlenmeyer flask, caused air to enter from the atmosphere through the glass tube and bubble up through the pasteurizing silage-milk and then to be withdrawn through the vacuum pump. In order to catch the vapors and air passing through the milk, a trap made of another but smaller erlenmeyer flask and half filled with milk which contained no feed flavors, was connected with the tube line between the pasteurizing flask and the vacuum pump. In operation, the air passed through the glass tube from the atmospheric end, bubbled through the hot pasteurizing milk, passed through the rubber connecting tube, bubbled through the cold feed-flavor-free "trap milk" and then passed out the top of the trap through the vacuum pump. As soon as the holding period was completed, the vacuum pump was turned off, cold water turned into the tank, and the hot pasteurized silage-milk was rapidly cooled down to 55°F. with constant agitation during cooling as well as during the pasteurizing period. A half pint sample was taken from the trap milk and another half pint sample was taken from the forced aerated pasteurized silage milk in the erlenmeyer

flask. They were both bottled, labeled, capped, and placed in the refrigerator for twenty-four hours to be judged later. A half pint of the milk which was used to collect the flavors was saved also. This milk had been pasteurized previously by conventional methods in the milk plant of the Dairy Department of Michigan State College.

After storage for twenty-four hours, the samples of raw silage milk, pasteurized aerated, pasteurized unaerated, vacuum pasteurized, forced aerated, trap milk, and non silage pasteurized control milk were each poured into clean beakers --- all numbered on the bottom with a key to their respective method of processing. The samples in the beakers were then judged organoleptically and ranked in order to the score given to them which varied from twenty-three to twelve. One or more judges scored and rescored the samples. The average score and criticism were recorded. The key numbers on the bottom of the beakers were then recorded beside the score and criticism for the sample. Two days later the same procedure of judging was repeated and the recording done on a different piece of paper. The first and third day scores and criticisms were then recorded in a data book in proper order, according to the series of key numbers.

RESULTS

The effect of various methods of pasteurization upon the removal of silage flavor from the milk.

The samples of silage flavored milk for this experiment were judged in rank as described on page 18 of this study. In order that each sample would have its proper place with relation to the intensity of feed flavor, the intensity of the feed flavor was computed by dividing the number of pounds of silage the cow ate by the number of pounds of milk that she produced. The figure for silage intensity shown on page 67, Table 13, indicates the number of pounds of silage which the cow ate one hour before milking per pound of milk that she gave.

The data covering a three month period are presented in Table 13. The intensity column indicates the strength of silage and the other columns indicate the method by which the milk was subsequently processed. The figures in these columns are the average of all scores given to this sample of milk by all the judges involved. The assumption was made that a score of 22 or better would be milk that would pass the average consumer uncriticised. On this assumption a line was drawn across the columns, indicating the point in silage intensity where the particular pasteurizing process would raise the score of the milk to 22.

A study of Table 13 shows that vacuum pasteurization and forced aeration pasteurization is superior to all other methods of pasteurization in driving off feedy flavors. According to the results of these studies, a cow may be fed 2.5 lbs. of corn silage one hour before milking for each pound of milk produced if the milk is to be pasteurized by vacuum pasteurization or forced aeration pasteurization. The score of the milk,

thus treated, will not be below 22. However, if the milk is pasteurized by any other method of pasteurization the feed flavor will be intense enough to drop the score below 22.

Of the common commercial methods, flash pasteurization was superior to the holder methods, with and without aeration, in eliminating the silage flavor and in producing a milk that would score 22 or above.

Pasteurization with aeration was superior to pasteurization without aeration in producing a milk that would not score below 22. In order to remove strong silage flavors from milk, a method of pasteurization must be used that will draw the volatile flavor producing substances out of the hot milk. Such methods are forced aeration during pasteurization and vacuum pasteurization.

An observation of the column on Table 14, labeled "Trap milk" which was exactly the same milk as the pasteurized control non-silage flavored milk, but which had been subjected to the process of passing through it the volatile feedy vapors arising from the forced aeration pasteurized milk, shows that the milk had decreased in score as compared to that of the pasteurized control milk, and had a pronounced feed flavor. This fact leads to the conclusion that the chemicals causing feed flavors are highly volatile and may be transferred from a feedy flavored milk to one without feed flavor and, thereby, reduce its score as a result of taking on the feed flavor.

Observations were made on the incidence of the oxidized flavor also. Limited data on the third day's storage seemed to indicate that flash pasteurization and vacuum pasteurization are superior to all other methods of pasteurization in preventing the development of the oxidized flavors, as no oxidized flavors were noted in these samples, whereas, oxidized flavors were noted in the other samples.

Table 13.

The effect of various methods of pasteurization on the score of silage flavored milk after the first day of storage.

Intensity of silage flavor. (lbs. silage/lbs. milk	The score of the milk when the sample was																	
		Holder pasteurized												Flash pasteurized		Commercial pasteurized milk		
		Unaerated			Aerated by:													
					Stirring			Bubbling air			Vacuum							
	Raw																	
6.20	18.	feed & acid feed	----		22.	feed	----			----				----		----		
5.10		& salty feed	----		20.	"	----			----				----		----		
5.00		& cowy	----		21.	"	20.	feed & heat		----				----		22.5	heat	
4.20	21.	feed	----		22.5	"	----			----				----		----		
4.00	19.	"	----		20.5	oxid	19.	feedy		18.5	feedy			----		23.		
2.60	18.	"	18.5	feed	20.5	feed	21.5	"		21.5	"			----		22.5	heat	
2.50	18.5	"	21.	"	21.5	"	22.	"		22.	"			21.5	feed	23.		
2.34	18.5	"	----		21.5	"	22.	"		----				21.5	"	23.		
2.10	17.	"	----		19.	acid & feed	----			----				22.	"	----		
1.80	19.5	"	22.	"	21.5	feed	21.5	feed & oxid.		22.5	feed			22.5	heat	22.5	"	
1.60	19.8	"	19.5	"	21.5	"	21.2	oxid.		22.	"			21.	"	22.25	"	
1.30	19.	"	----		22.3	"	----			----				----		----		
1.05	21.	"	----		23.		----			----				----		----		
1.00	20.	"	----		22.1	"	----			----				----		----		
.99	18.	acid & feedy	----		22.	"	----			----				----		----		
.94	21.5	feedy	----		22.2	"	----			----				----		----		
.90	19.5	"	----		22.1	"	----			----				----		----		
.79	20.	"	----		23.		----			----				----		----		
.67	23.		----		21.	oxid	21.5	oxid.		22.5	heat			----		22.	heat	
.50	23.		----		22.	"	----			----				----		22.5	"	
Mean	19.5		20.2		21.5		21.35			21.5				21.6		22.4		

Table 14.

The effect upon the score and flavor when passing the vapors from corn silage milk during pasteurization through cold silage flavor-free milk.

Intensity of silage flavor. (lbs. silage/lbs. milk	Flavor score and criticism of:			
	Raw milk	Holder pasteurized air-bubbled milk	Trap milk	Control (Pasteurized, no feed flavor)
		After one day at 40°F.		
4.00	19.0 feed	19. feedy	20. feedy	23. ----
2.60	18.0 "	21.5 "	21.5 "	22.5 heat
2.50	18.5 "	22.0 "	22.0 "	23.
1.80	19.5 "	21.5 feed & oxid.	22. "	22.5 heat
		After three days at 40°F.		
1.80	18. feed & acid	21. oxid.	20. feedy	23.

Figure 9. Apparatus used for vacuum pasteurization of the milk at 143°F. for 30 minutes.

Figure 10.

Figure 10. Apparatus used for forced aeration during holder pasteurization (143°F. for 30 min.), showing trap for collecting the feedy flavored vapors.

The effect of various methods of pasteurization upon the removal of alfalfa silage flavor from the milk.

Using the same methods of treatment with alfalfa silage milk as were employed with the corn silage milk samples, data were obtained on this part of the experiment. These are presented in Tables 15 and 16.

Considerably less alfalfa silage than corn silage had to be fed to the cow one hour before milking in order not to impart an objectionable flavor to the milk which would reduce the score below 22.

As in the corn silage experiment, vacuum pasteurization and forced aeration were again superior to other methods of pasteurization in producing pasteurized milk which would score 22 or above after one day of storage.

After storing the samples for three days they were judged again as noted by the data in Table 16. A marked difference was found between the results of the various methods of pasteurization. Vacuum pasteurization was by far superior to the other methods of pasteurization in producing a milk that kept its flavor and retained a score of 22 after three days of storage at 40°F. The vacuum pasteurized samples had less oxidized flavors than any other samples.

As with corn silage flavor, the alfalfa silage flavor was highly volatile and could be transferred in part by drawing air through the feed flavor sample into one of excellent flavor, to the extent that a strong feed flavor was imparted to the latter.

Table 15.

The effect of various methods of pasteurization on the score of silage flavored milk after the first day of storage.

Intensity of silage flavor. (lbs. silage/lbs. milk	Flavor score of the milk when the milk was					
		Holder pasteurized (143 F. - 30 min.)				
	Raw	Unaerated	Aerated by: Stirring	Bubbled air	Vacuum	Commercial pasteurized milk
2.	20. feed	19. feed	20. feed	22.0 feed	22.5 feed	23.
1.6	21. "	22. "	21. "	----	----	22. heat
1.2	21.5 "	21.5 "	21. "	19.0 feed & oxid.	21.0 feed	23.
.73	21.5 "	21. "	20. "	21.5 feed & oxid.	22.0 "	22. heat
.42	18. "	21.5 feed & oxid.	21.5 feed & oxid.	22.5 feed	22.5 "	22. grassy
.40	20.5 "	20. feed	19. feedy	22.0 "	22.0 "	22. "
.22	23. ----	21.5 "	21.5 "	22.0 "	22.0 "	21.5 "
.18	21.5 feed	22.5 "	22. "	23.0	22.5 "	22.5 "
.08	23.	22. heat	23. ----	23.0 ----	23.0 ----	22.5 "
Mean	21.10	21.20	21.00	21.8	22.10	22.30

Table 16.

The effect of various methods of pasteurization on the score of silage flavored milk after the third day of storage.

Intensity of silage flavor. (lbs. silage/lbs. milk	Flavor score of the milk when the milk was											
			Holder pasteurized (143°F. - 30 min.)								Commercial pasteurized milk	
	Raw		Unaerated		Aerated by: Stirring		Bubbled air		Vacuum			
2.0	20.	feedy	21.	feed	18.	feed & oxid.	19.	feed & oxid.	19.	feed & oxid.	22.	tallowy
1.6	20	"	21.	"	19.	oxid.	-----		-----		18.	oxid.
1.2	19.	"	19.	"	19.	feedy	20.	oxid. slight	21.	feedy	22.	feed or heat
.73	21.5	"	20.5	"	20.	"	21.	oxid.	22.	"	16.	oxid.
.42	18.	feedy & acid.	19.	feedy & oxid.	22.	"	23.	----	22.5	"	21.5	grassy
.40	18.	feedy & oxid.	16.	feedy & oxid.	19.5	feedy & oxid.	20.	feed & oxid.	18.	oxid.	18.	oxid.
.22	18.	feed & oxid.	21.5	feedy	21.5	feed	21.5	feed slight	22.5	feed	21.5	feedy
.18	18.	acid	21.5	stale	18.	oxid.	19.	acid.	22.5	flat slight	18.	acid
.08	23.	----	20.	acid	19.	"	18.	oxid	20.	acidy	21.	feedy
Mean	19.5		19.9		19.5		20.06		20.9		19.7	

Table 17.

The effect upon the score and flavor of passing the vapors from alfalfa silage milk through cold silage flavor-free milk.

Intensity of silage flavor. (lbs. silage/lbs. milk	Flavor score and criticism of:			
	Raw milk	Holder pasteurized air-bubbled milk	Trap milk	Control milk (Pasteurized no feed flavor)
		After one day at 40°F.		
.22	23. ----	22. feed	20. feed	21.5 grassy
.18	21.5 feed	23. ----	21.5 "	22.5 "
		After three days at 40°F.		
.22	18. feed acid	21.5 feed	19. feed & oxid.	21.5 feedy
.18	18. acid	19. slight acid	20. feed & stale	18. acid.

DISSCUSSION

The finding that considerably more corn silage than alfalfa silage must be fed to a cow to produce a pronounced feed flavor is in agreement with the conclusions of Gamble and Kelly (1922) who stated: "Legume silage affects the flavor and odor of milk to a greater extent than an equal amount of corn silage." There are two different flavors involved: corn silage flavor in milk is sweeter and less harsh and offensive a flavor than alfalfa silage flavor. Hence, it is possible that a certain amount of corn silage in milk does not produce an objectionable flavor, while a similar amount of alfalfa silage flavor is objectionalbe to the taste.

Previous investigators, working with feed flavors, have stated that a certain weight of feed may be fed one hour before milking without producing offensive odors and flavors in the milk. Such statements do not seem to hold true for each cow. As the milk production varies, the volume of flavor in the milk from a given quantity of feed would vary also. Hence, it appears more logical to calculate the pounds of feed fed at a given time per pound of milk produced in order to ascertain the relationship between objectionable feed flavors and the milk. Several times during the experiment this assumption was checked by feeding a given quantity of silage to each of a group of individual cows varying in their level of milk production. The intensity of the flavors of the milk varied with the strongest flavor in the milk from the cow producing the least amount of milk. Dilution of several samples of feed flavored milk by unflavored milk reduced the feed flavor intensity to a point where it

could not be detected. This effect has practical significance. Commercial dairies have observed that one can of feed flavored milk will not affect appreciably the flavor of the entire milk supply. Hence, leniency to certain feed flavors has been experienced in grading milk for pasteurization.

The corn silage milk which was pasteurized unaerated had less perceptible feed flavor than unpasteurized (Table 13). This finding is in agreement with the conclusions of Part I of this study. Gamble and Kelly (1922) stated that aeration over a surface cooler removes some degree of silage flavor. McCandlish and Leitch (1932) and Weaver et al. (1935) all express the same opinion.

The fact that the chemical which produced the silage flavor was volatile enough to be drawn out of feed flavored milk and captured in cold unflavored milk by bubbling air through the hot pasteurized milk, indicates that a method of vigorous aeration during pasteurization would tend to remove more feed flavor. Such a method was employed in forced aeration and vacuum pasteurization. Data in Table 13 for corn silage and Table 15 for alfalfa silage show that the milk which had been pasteurized by forced aeration and vacuum pasteurization might have had a more intense feed flavor, and yet upon processing would have had a flavor meriting a score of 22. Hence, aeration, whether gentle or vigorous during pasteurization, aids in the removal of feed flavors from the milk. This conclusion is in agreement with those of Hunziker (1927), Mac Donald and Crawford (1927), McCandlish and Leitch (1932), and Weaver (1935). The latter stated that aeration would remove about one-half the off flavors imparted to milk by alfalfa hay. This study shows that alfalfa silage raw milk, containing a silage in-

tensity of 0.08, will score 22, while aerated pasteurized milk of an original intensity of 0.20 will score 22. Allowing for the difference in pasteurization with aeration and aeration alone and also for the slight difference in the flavor imparted to the milk by the alfalfa hay and alfalfa silage, just about one-half of the feed flavors are removed by aeration. Thus, the findings of this study coincide with those of Weaver (1935).

The scores of the milk after three days of storage show that all the milk decreased in score (Table 16.). Furthermore, the oxidized flavors tended to develop to a large extent in the milk subject to all methods of pasteurization excepting that milk which was vacuum pasteurized. Many investigators have shown that pasteurized milk develops more oxidized flavors than unpasteurized milk. This was substantiated in Part I of the present study. Brown, Thurston, and Dustman (1936b) concluded that aeration over a surface cooler did not per se cause more oxidized flavors to develop than cooling by passage through an internal tubular cooler. However, the results of this study indicate that pasteurization with aeration, particularly vigorous forced aeration, increases the development of oxidized flavors. The possible explanation is that forcing air through heated milk may (1) oxidize the fatty constituents resulting in the off flavor, (2) oxidize natural reducing substances present, and (3) supply ample oxygen from the air so that these chemical changes may proceed. Milk subjected to vacuum pasteurization developed less oxidized flavors than any other pasteurized aerated milk. The explanation would be the reverse of the effect of forced aeration. Maintaining a vacuum during pasteurization would draw from the milk not only volatile feed vapors but any gases dissolved in

the milk. These gases are mostly carbon dioxide, nitrogen, and oxygen --- in short, air. Withdrawal of oxygen would tend to retard if not prevent any oxidation process in the milk. Hence, the incidence of oxidized flavor in vacuum pasteurized milk would be reduced greatly.

This is in agreement with the work of Hand, Guthrie, and Sharp (1938) who showed that vacuum cooling of milk not only left a higher vitamin C content but also rendered the milk less susceptible to oxidative changes. Vitamin C is inactivated by blowing air through hot milk as shown by the work of associates of Rogers (1935).

SUMMARY

Samples of feed flavored milk were obtained over a periof of three months from a Holstein cow fed varying amounts of corn and of alfalfa silage one hour prior to milking. The intensity of the feed flavor was found to be proportional to the amount of feed which was fed, the pounds of milk produced being relatively constant. Consequently, the intensity of the feed flavor may be expressed by the dividend obtained when the pounds of milk produced are divided into the pounds of feed which were fed. On this basis, corn silage may be fed according to the accompanying table without appreciably reducing the flavor score of the milk.

Type of milk	Pounds of corn silage per pound of milk produced.
Raw	0.70
Holder pasteurized (143°F. - 30 min.)	
Unaerated	1.00
Aerated (stirred)	1.50
Aerated (air bubbled)	2.50
Aerated (vacuum)	2.50
Flash pasteurized (160°F. - 15 sec.)	2.20

Likewise alfalfa silage may be fed according to the accompanying table without appreciably reducing the flavor score of the milk.

Type of milk	Pounds of alfalfa silage per pound of milk produced.
Raw	0.08
Holder pasteurized (143°F. - 30 min.)	
Unaerated	0.20
Aerated (stirred)	0.20
Aerated (air bubbled)	0.45
Aerated (vacuum)	0.75

Vacuum pasteurization and forced aeration holder pasteurization were superior to all other methods employed in removing corn and alfalfa silage flavors from such milk. However, forced aeration, as well as unaerated and aerated holder pasteurization resulted in a greater incidence of oxidized flavors than vacuum or no pasteurization.

Storing the alfalfa silage milk three days tended to produce oxidized flavors in the milk pasteurized by all methods except vacuum pasteurization and flash pasteurization.

The chemical responsible for feed flavor in silage milk was found to be quite volatile and was capable of being transferred from a strong flavored sample to an unflavored one, thus lessening the intensity of flavor in the former and imparting it to the latter.

One can of silage flavored milk will not necessarily spoil the flavor of a large batch of milk. Sufficient excellent flavor milk may be added to the silage milk so as to reduce the silage intensity to the extent that pasteurization will remove the remainder.

LITERATURE CITED

1. Anonymous
   1936 The flavor of milk.
   N. Y. State Agr. Exp. Sta. Cir. 167.

2. Associates of Rogers
   1935 Fundamentals of Dairy Science.
   2nd Ed., 616 p. illus. Reinhold Publishing Corp., New York.

3. Ayers, S. H. and Johnson, W. J.
   1914 Removal of garlic flavor from milk and cream.
   U. S. D. A. Farmers Bull. 608.

4. Babcock, C. J.
   1923 Effect of feeding green alfalfa and green corn on flavor and odor of milk.
   U. S. D. A. Dept. Bull. 1190. p. 12.

5. _____
   1924 Effect of feeding cabbages and potatoes on the flavor and odor of milk.
   U. S. D. A. Dept. Bull. 1297. p. 12.

6. _____
   1925a Effect of feeding green rye and green cowpeas on the flavor and odor of milk.
   U. S. D. A. Dept. Bull. 1342. p. 8.

7. _____
   1925b Effect of garlic on flavor and odor of milk.
   U. S. D. A. Dept. Bull. 1326. p. 9.

8. _____
   1927 Effect of some succulent feeds on the flavor and odor of milk.
   U. S. D. A. Tech. Bull. 9. p. 5.

9. _____
   1930 Abnormal flavors of milk.
   Proc. 23 Ann. Convention of the Internat. Assoc. Milk Dealers, Lab. Sect. p. 20.

10. Brown, W. C., Thurston, M., and Dustman, R. B.
   1936 a Oxidized flavor in milk. II. The effects of homogenization, agitation and freezing of milk on its subsequent susceptibility to oxidized flavor development. J. Dairy Sci. 19. p. 671.

11. Brown, W. C., Thurston, L. M., and Dustman, R. B.
1936b Oxidized flavor in milk. III. The time of copper contamination during production and processing, and aeration versus no aeration as related to oxidized flavor development. J. Dairy Sci. 19. p. 759.

12. Dahle, C. D. and Palmer, L. S.
1937 The oxidized flavor in milk from the individual cow. Penn. Agr. Exp. Sta. Bull. 347. p. 26.

13. Gamble, J. A. and Kelly, E.
1922 Effects of silage on flavor and odor of milk. U. S. D. A. Dept. Bull. 1097. p. 24.

14. Gray, D. and Eaton, W. H.
1916 Experiments with dairy cattle. Onion flavor. N. Car. Agr. Exp. Sta. Rpt. p. 39.

15. _____ and _____
1917 Experiments with dairy cattle. Onion flavor. N. Car. Agr. Exp. Sta. Rpt. p. 51.

16. Fleischmann, W.
1829 The Book of Dairying. 1st. Ed. 329 p. illus. Blackie & Sons, Glasgow.

17. Hand, D. B., Guthrie, E. S., and Sharp, P. F.
1938 Effect of oxygen, light and lactoflavin on the oxidation of vitamin C milk. Sci. 87: 2263. pp. 439-441.

18. Harley, W.
1829 The Harleian Dairy System. 1st. Ed. 288 p. illus. James Ridgway, Piccadilly, London.

19. Hunziker, O. F.
1927 The Butter Industry. 2nd Ed., 682. p. illus. Author. Lagrange, Ill.

20. Kellner, O.
1915 The Scientific Feeding of Animals. 1st. Ed. xlll. 404 p. illus. The Macmillan Co., New York.

21. King, F. H. and Farrington, E. H.
1897 Influence of silage odors in the air on milk. Wis. Agr. Exp. Sta. Bull. 59. p. 25.

22. Mac Donald, M. B. and Crawford, Esther M.
1927 Removal of onion or garlic flavor and odor from milk. Tenn. Agr. Exp. Sta. Cir. 26. p. 1.

23. McCandlish, A. and Leitch, R. H.
1932 Foods and flavours of milk. West of Scotland Agr. Eol. Bull. 126.

24. Marquardt, J. C. and Dahlberg, A. C.
1934 Pasteurized milk flavor and creaming power as affected by heating medium temperature and pasteurizer linings. N. Y. Agr. Exp. Sta. Tech. Bull. 223. p. 16.

25. Powell, M. E.
1938 Flavor and bacterial changes occurring during storage of sweet cream which has been flash pasteurized at various temperatures. J. Dairy Sci. 21. p. 219.

26. Quinn, J. D. and Burgwald, L. H.
1933 High short holding and low long holding. Milk Plant Monthly. 22:2. p. 26.

27. Riddet, W. and Valentine, G. M.
1923 The effect of flash pasteurization on weed flavour of milk. New Zealand. Jour. of Agriculture 44. p. 276.

28. Roadhouse, C. L. and Henderson, J. L.
1932 The relation of the soluble portion of alfalfa to the rapid absorption of feed flavor of milk. J. Dairy Sci. p. 299.

29. _____ and _____.
1935 Flavors of milk and their control. Calif. Agr. Exp. Sta. Bull. 595. p. 30.

30. _____ and _____.
1937 Regulating the feeding of certain roughages to minimize their influence on flavor of milk. J. Dairy Sci. 20. p. 682.

31. Ross, H. E.
1937. Homogenization as a prevention of oxidized flavor. Milk Plant Monthly 26: 4, 5.

32. Sharp, P. F., Trout, G. M. and Guthrie, E. S.
1936 The relation of oxidized flavor to pasteurization temperature. 10th Ann. Rpt., N. Y. State Assoc. of Dairy and Milk Inspectors, pp. 143-164.

33. Tracy, P. H. and Ruehe, H. A.
1931 Relation of certain plant processes and flavor development in milk. J. Dairy Sci. 14. p. 254.

34. Tracy, P. H., Ruehe, H. A. and Ramsey, R. J.
1933 Certain biological factors related to tallowiness of milk and cream. Ill. Agr. Exp. Sta. Bull. 389.

35. Trout, G. M.
1932 Sources of some abnormal flavors of milk. Mich. Agr. Exp. Sta. Quart. Bull. 14. p. 141.

36. _____ and Taylor, G. E.
1935 Effect of beet tops on the flavor and odor of milk. Mich. Agr. Exp. Sta. Quart. Bull. 18. p. 37.

37. _____ and Sharp, P. F.
1937 The Reliability of Flavor Judgments with Special Reference to the Oxidized Flavor of Milk. N. Y. (Cornell) Agr. Exp. Sta. Memoir 204.

38. _____
1937 Off flavors in raw and pasteurized milk. Proc. of 30 Ann. Convention of the Internat. Assoc. of Milk Dealers. Lab. Sect. p. 228.

39. _____ and Gould, I. A.
1938 Homogenization as a means of stabilizing the flavor of milk. Mich. Agr. Exp. Sta. Quart. Bull. 21. pp. 21-31.

40. Weaver, E., Fouts, E. L. and Kuhlman, A. H.
1934 Effect of alfalfa hay on milk flavor. Abs. 29 Ann. Meeting. D. Sci. Assoc.

41. _____
1935 Effect of alfalfa hay on milk flavor. J. Dairy Sci. 18. p. 61.

42. _____, Fouts, E. L, and McGilliard, R. C.
1935 Frequency of flavor defects in milk. J. Dairy Sci. 18. p. 467.