THE KEEPING QUALITY OF PASTEURIZED MILK

by

MING-fang Li

A Thesis Submitted to
The Faculty of Graduate Studies and Research
The University of Manitoba
In Partial Fulfilment of the Requirements
For the Degree of
Master of Science
May 1957

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Experiments have been carried out to determine the effect of the method of pasteurization, the storage temperature and the number of days in storage on the keeping quality of pasteurized milk. Milk obtained from the University dairy was pasteurized by the H.T.S.T. and vat methods and samples were stored at 35° F., 40° F., and 50° F. for a period up to 18 days. Samples were analyzed at three day intervals for bacterial count, flavor, pH and acidity.

Milk pasteurized by the H.T.S.T. method at 161° F. for 16 seconds produced a better product from the standpoint of bacterial count, pH and flavor than milk pasteurized at 143° F. for 30 minutes.

The storage temperature had a significant effect on the bacterial count, pH, acidity and flavor of the pasteurized product. Storage at high temperatures tend to inhibit the development of oxidized flavor. However, storage at 50° F. over a long period of time induced the development of acidity and the souring of milk. Pasteurized milk with a low bacterial count should perhaps be stored at 40° F. rather than at 35° F. Milk with a high bacterial count should be stored at lower temperatures (35° F.). The proper storage temperature seems to be determined by the quality of the pasteurized milk as well as by the length of storage period desired before consumption.

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INTRODUCTION

Many changes have taken place in the dairy industry in Manitoba during the last five years. Paper containers have largely replaced glass bottles for the distribution of milk. Roads throughout the province have been greatly improved and a large part of the milk is now transported by truck. These changes have resulted in a centralization of the milk plants in the province. A few widely scattered plants now process almost all of the fluid milk used in the province. Milk is now being delivered from the City of Winnipeg to all parts of Manitoba and even to Saskatchewan. This may involve transportation over distances of 600 miles for example to Flin Flon, Manitoba. This milk may be up to 14 days old before it is finally consumed.

The following project was conducted to determine the effect of storing pasteurized milk at various temperatures for periods up to 18 days. Milk was pasteurized by the High Temperature Short Time method (161° F. for 16 seconds) and by the vat method (143° F. for 30 minutes) and samples were stored at 35° F., 40° F., and 50° F. for periods up to 18 days. Samples were analyzed at three day intervals for bacterial count, flavor, pH and acidity.

This thesis reports the results of this investigation.

REVIEW OF LITERATURE

Bacteriological Deterioration of Pasteurized Milk.

Thermoduric and Thermophilic Bacteria: Bacteriological deterioration of pasteurized milk is caused either by bacteria which survive pasteurization or by bacteria which enter the milk after pasteurization. Those bacteria which survive pasteurization in considerable numbers are considered by the Dairy Industry to be thermoduric bacteria. These bacteria are capable of growing rapidly in milk over a wide range of temperature. Those bacteria which grow and multiply at pasteurization temperatures are called thermophilic bacteria. They grow best at temperatures between 50° C. and 60° C. Above and below this range reproduction is retarded, Olson (48).

These organisms gain entrance to the milk from the udder, from the equipment with which the milk comes in contact and from the dust in the air at the time of milking. Hileman (36) and Abdel-malek (1) considered that the cows udder was the main source of thermoduric bacteria. Levowitz (42), however, believed that the udder did not contribute to the thermoduric count sufficiently to cause it to exceed municipal milk standards. Dirty milking machines and utensils, especially if dried milk solids were present, were shown to be excellent sources of contamination by Galesloot (24) and Thomas (58). The importance of proper cleaning and sanitizing of utensils was also indicated by Dotterer (17). Dust in the stable air at milking time was reported by Mack (43) as another vital source of contamination since feed, bedding and soil harbored thermophilic organisms.

Alexander (2) reported that microbacteria and micrococci together with streptococci, aerobic sporeforming bacilli and non-sporing rods survived H.T.S.T. pasteurization. Fabian (22) classified the most common bacteria which survived pasteurization as Micrococcus albus, M. aureus, M. candidus, M. conglomeratus, M. epidermis, M. luteus, M. varians, Streptococcus thermophilus, S. liquefaciens, S. bovis, S. glycerinaceous, S. inulinaceous, S. fecalis, S. zymogens, Sarcina lutea, S. rosa, Bacillus cereus, and B. subtilis. The most common thermophilic bacteria were B. stearothermophilus, Clostridium thermosaccharolyticum and C. nigrificans. This view was supported by Galesloot (25, 27) and Abdel-malek (1).

Galesloot (24) reported that microbacteria were more prevalent during the summer months and thermoduric streptococci were more prevalent during the winter months. Thomas (59), however, found that the thermoduric organisms were more numerous in summer and early autumn than during the winter and early spring months.

There is some doubt as to the relationship between the Standard Plate Count of pasteurized milk and the keeping quality as indicated by Ashton (5) and Galesloot (26). Thomas (57) found that a high proportion of milk samples of good keeping quality had low thermoduric counts and nearly half the samples of poor keeping quality had high thermoduric counts.

Psychrophilic Bacteria: Those bacteria which have optimum growth rates at comparatively low temperatures are considered to be psychrophilic. Incubation temperatures below 7.5° C. for 15 days or longer were recommended where conducting standard plate counts on such organisms, since at 10° C. thermoduric organisms which are not considered to be true psychrophiles began to grow, Atherton (8) and Boyd (11). However, in milk refrigerated at 35° F. - 40° F. Nelson (46) obtained the highest counts where the plates were incubated between 21° C. and 25° C. Watrous (64), Atherton (7) and Van Der Zant (63) confirmed this viewpoint.

Sherman (54) and Olson (49) have reported that psychrophilic bacteria im milk are in general Gram negative, non-sporeforming rods. Erdman (20) classified 190 psychrophilic cultures isolated from milk and cream as Pseudomonas, Lactobacillus, Streptococcus, Aerobactor, Flavobacterium, and Escherichia in descending order of importance. Within a group of 41 psychrophilic cultures isolated from water and butter, 28 were classified as belonging to the genus Pseudomonas, 5 to the genus Flavobacterium, 6 to the genus

Alcaligenes, one to the genus Achromobacter, and one was a non-lactose fermenting yeast, Jezeski (38).

Burgwald (12) found that the psychrophilic bacteria which developed in milk during refrigerated storage were primarily responsible for the deterioration of the product. This view was supported by Davis (16).

The general opinion is that the majority of true psychrophiles are destroyed at pasteurization temperatures, Thomas (56), Rogick (53), and Olson (50). Consequently, their presence in pasteurized milk in relative high numbers could be considered as an index of post-pasteurization contamination, Trout (62) and Hempler (35). Contamination could be prevented by the use of sanitary equipment England (19) and by the use of potable water supplies, Parker (51).

The Keeping Quality of Pasteurized Milk.

Boyd (10) stated that in his experiments the average keeping quality of commercially pasteurized and homogenized milk stored at 40° F. was found to be from 13 to 18 days based on a flavor score of 33, (from the U.S.D.A. Bureau of Dairy Industry Score Card for milk) and from 8 to 11 days based on a standard of not over 50,000 bacteria per ml. When duplicate samples were stored at 33° F., the average keeping quality of the milk was extended to 11 to 14 days.

The flavor deterioration was correlated with the growth of psychrophilic bacteria.

Atherton (8) found that the first perceptible indication of deterioration of milk at low temperatures seemed to be a loss of stability of the casein. There was little change in the acidity and a slow change in flavor even with a rapidly increasing bacterial count.

Development of Off Flavors during the Storage Period.

Oxidized Flavor: Roland (52) found that oxidized flavor was the predominating flavor encountered in pasteurized milk. Milk of a high fat content seemed to be more susceptible to this flavor. Thurston (60) claimed that lecithin rather than butter fat appeared to be the constituent affected. By the removal of lecithin and related substances by separation, Mucha (44) was able to decrease the sensitivity to the development of this off flavor.

Iron and copper were found by Greenbank (29) to be ideal catalysts for the development of this flavor. Light may inhibit, promote, or have no effect on the development of the flavor depending on the metallic contamination of the milk and the intensity of irradiation.

Homogenization and prolonged agitation at low temperatures reduce the susceptibility to the development of oxidized flavor, Thurston (61) and Guthrie (32). The experimental evidence of Larsen (41) indicated there was no correlation between the Eh and the inhibiting effect of homogenization.

Weinstein (65) added 35 mg. of ascorbic acid per litre and retarded the development of the oxidized flavor for 72 hours in milk stored at 45° F. Bell (9) found the addition of ascorbic acid lowered the Eh and greatly deferred, but did not prevent the development of an oxidized flavor in frozen milk. Chilson (13) stated that no oxidized flavor developed in ascorbic acid fortified milk (1.5 gm. per 100 lbs.) after 5 or 7 days' storage but rapid reduction of ascorbic acid in milk, either by exposure to direct sunlight or through the addition of 3% H_2O_2, resulted in no oxidized flavor over a 5-day storage period. He believed that ascorbic acid was a contributing factor in the development of this off flavor. Guthrie (31) also noted that when the ascorbic acid was eliminated oxidized flavor did not develop.

Greenbank (29, 30) believed that this off flavor was the result of an intermediate oxidation product and that the development of the flavor in milk may be inhibited by reducing or by oxidizing agents. Such an oxidation may be represented as follows:

R------	RO-----	RO_2-----
No oxidized flavor	Oxidized flavor	No oxidized flavor

Roland (52) found that the bacterial counts on milk with an oxidized flavor were generally lower than counts on milk free from this defect. When Cone (14) added a large inoculation of oxidase producing gram-negative bacteria to a milk sample the development of oxidized flavor was markedly inhibited.

Greenbank (29) claimed that the oxidized flavor developed by milks held in storage increased in intensity with decreased storage temperatures. The probable explanation may be related to the dissolved oxygen content at different temperatures upon the relative rate of two or more successive reactions that may be involved in the formation and destruction of the flavor.

Other Factors Affecting the Keeping Quality.

Method of Pasteurization: Yale (66) found that none of the evidence collected showed any significant difference between the two methods of pasteurization on the cream layer, flavor, reduction of bacterial counts or destruction of Escherichia-Aerobactor types of bacteria present.

Fabian (21) stated that we should expect to find more thermophilic bacteria in milk pasteurized at 142° F. to 145° F. for 30 minutes than in the milk pasteurized at 160° F. to 161° F. for 15 to 16 seconds, and conversely we should expect to find more thermoduric bacteria in milk pasteurized at 160° F. to 161° F.

Hileman (37) found that H.T.S.T. pasteurization resulted in higher bacterial counts than pasteurization of the same milk in the laboratory at 143° F. to 144° F. for 35 minutes. Ashton's (5) investigations confirm these findings, but the keeping quality of vat pasteurized milk was inferior to that of the H.T.S.T. pasteurized milk.

Production and Processing Sanitation: Corash (15) and Hammer (33) stressed that pasteurization could not convert low quality milk into high quality milk. The sale of a high quality product depended on clean milk production and sanitary processing.

Harding (34) and Kasli (40) found that a better quality of milk could not be obtained unless clean utensils and bottles were used, and special attention was paid to proper cooling, before as well as after pasteurization. Moisture left in the cleaned cans caused marked increases in bacterial counts. According to Atherton (6) the elimination of cans and the improvement of cooling by conversion to bulk tanks and bulk tank pick up at the farm contributed to improved flavor and lower bacterial counts in milk.

Improperly cleaned and sanitized pipelines constituted an important source of general and thermoduric contamination of raw milk. Milk pipelines could be sanitized effectively by the use of procedures which included either chlorination or hot water at 185° F. as a germicidal agent, Alexander (3).

Circulation through the equipment of 100 to 125 p.p.m. available chlorine solution for at least 5 minutes, and spraying the surfaces of vat walls with 400 p.p.m. of quaternary ammonia solution was advised by England (19). The quaternary ammonia compounds generally were more effective against Gram-negative species, Johns (39). Mueller (45) found that iodine liquid and iodine detergent-sanitizer products were equally effective in bactericidal properties when 25 p.p.m. of available iodine were compared with 100 p.p.m. of available chlorine in killing *E. coli* *S. Typhosa*, *M. pyrogenes*, and *Ps. aeruginosa*.

Investigations by Alexander (3) and Fortney (23) indicated that a high degree of sanitation could be achieved by the installation of cleaned-in-place pipelines thus eliminating the need for dismantling the pipelines.

METHODS

Samples.

The raw milk used in the experiments was obtained from the Holstein herd at the University of Manitoba. The milk was thoroughly mixed and then divided into two lots. One lot was pasteurized in a High Temperature Short Time unit at 161° F. for 16 seconds and the other lot was pasteurized in a vat at 143° F. for 30 minutes. Sixty samples were taken from the processing line after they had been processed in the regular manner followed by the dairy. The first and last bottles off the line were not used. The samples were then stored at 35° F., 40° F. and 50° F. A parchment paper was fastened over the top of each bottle to prevent contamination from the air since preliminary trials indicated that contamination with yeast could occur around non-hooded milk bottle caps.

Analysis of the Samples.

The samples were analyzed at three day intervals for a period of 18 days. The following determinations were made:

Bacterial Counts: The milk samples were plated in two series of duplicate plates in two dilutions with tryptone glucose yeast agar (4). One series was incubated at 32° C. for 48 hours and the other series at 25° C. for 72 hours. The average count used in the data was determined according to Standard Methods for the Examination of Dairy Products (4).

Coliform Counts: Counts were made by plating 1 ml of the sample or a dilution of the sample in violet red bile agar. If necessary brilliant green lactose bile broth or eosin methylene blue agar was used to confirm the test (4).

Acidity and pH: The acidity was determined by titration with 0.1N NaOH (the result was expressed as percent lactic acid). The pH values were determined with a Beckman glass electrode pH meter model H2 (28). The pH data were statistically analyzed using direct pH values according to the method of Shiue (55).

Flavor Score: The flavor was judged according to the score card approved by the American Dairy Science Association. Each flavor was classified as slight, distinct or strong according to its intensity. The points deducted for the off flavors and intensities were as suggested by G. M. Trout and associates (47). The maximum score alloted was 41 out of a possible 45, and the minimum score was 0. A score of 0 indicates that the quality of the milk was so low that it would not be suitable for fluid consumption.

The data obtained in the above trials was then analyzed statistically.

RESULTS

The bacterial counts, flavor scores, pHs and acidities of the samples will be found in Tables 1 - 16 in the Appendix. (see page 39). The analyses of variance of the above characteristics will be found in Tables I - IV below.

Table I. The Analysis of Variance of the Bacterial Counts.

Variation	df	SS	MS	F
Samples	7	304.323	43.475	19.99**
Methods	1	112.718	112.718	51.85**
Storage temperatures	2	373.192	186.596	85.83**
Temp. x method	2	4.627	2.314	1.06
Error (a)	35	81.110	2.174	
Total (a)	47	875.970		
Storage days	6	443.873	73.978	4.20**
Days x methods	6	44.646	7.441	5.75**
Days x temp.	12	121.895	10.158	7.85**
Day x temp. x method	12	15.530	1.294	2.41**
Error (b)	252	134.985	0.536	
Total (b)	335	1636.899		

Least significant difference for storage temperature is 0.399.
L.S.D. for days in storage is 0.293.

** indicates that the F value is significant at the 1% level.
* indicates that the F value is significant at the 5% level.

Table II. The Analysis of Variance of the Flavor Scores.

Variation	df	SS	MS	F
Samples	7	2652.461	378.923	3.04*
Methods	1	943.361	943.361	7.59**
Storage temp.	2	4344.906	2172.453	17.48**
Temp. x method	2	2110.580	1055.290	8.49**
Error (a)	35	4349.019	124.258	
Total (a)	47	14400.327		
Storage days	6	9386.909	1564.484	2.60*
Days x methods	6	634.065	105.677	<1
Days x temp.	12	5996.731	499.728	3.94*
Day x temp. x method	12	1518.885	126.573	3.23**
Error (b)	252	9862.603	39.173	
Total (b)	335	41799.520		

L.S.D. for storage temperature is 3.02.
L.S.D. for days in storage is 2.50.

Table III. The Analysis of Variance of the pH Values.

Variation	df	SS	MS	F
Samples	7	6.369	0.9098	2.96*
Methods	1	2.220	2.220	7.23*
Storage temp.	2	19.789	9.8949	32.24**
Temp. x method	2	4.167	2.0835	6.78**
Error (a)	35	10.744	0.3069	
Total (a)	47	43.249		
Storage days	6	8.117	1.3528	2.87*
Days x method	6	1.500	0.2500	1.10
Days x temp.	12	14.653	1.2211	5.50**
Days x temp. x method	12	2.666	0.2222	3.10**
Error (b)	252	18.043	0.0716	
Total (b)	335	88.228		

L.S.D. for storage temperature is 0.150.
L.S.D. for days in storage is 0.107.

Table IV. The Analysis of Variance of the Acidities.

Variation	df	SS	MS	F
Samples	7	0.3235	0.0462	1.66
Methods	1	0.1869	0.1869	6.72*
Storage temp.	2	1.4437	0.7218	25.96**
Temp. x method	2	0.4337	0.2169	7.80**
Error (a)	35	0.9731	0.0278	
Total (a)	47	3.3609		
Storage days	6	0.5911	0.0985	<1
Days x method	6	0.1270	0.0212	1.13
Days x temp.	12	1.0354	0.0863	4.61**
Days x temp. x method	12	0.2241	0.0187	3.87**
Error (b)	252	1.2157	0.0048	
Total (b)	335	6.5542		

L.S.D. for storage temperature is 0.045.

The H.T.S.T. method of pasteurization on the average gave lower bacterial counts, higher flavor scores, higher pH values and lower acidities than the vat method. The mean of the logarithm of the bacterial count of the H.T.S.T. pasteurized milk was 4.25 and for the vat pasteurized milk it was 5.45. The mean of the flavor scores for H.T.S.T. pasteurized milk was 31.4 and for vat pasteurized milk it was 28.1. The analyses of variance (Tables I and II) show that the differences between the two methods on the basis of bacterial count and flavor are significant at the 1% level. The mean of the pH values for the H.T.S.T. pasteurized milk was 6.58 and for the vat pasteurized milk it was 6.42.

The mean of the acidity for the H.T.S.T. pasteurized milk was 0.19% and for the vat pasteurized milk it was 0.23%. The analyses of variance (Tables III and IV) show that the differences between the methods on the basis of pH and acidity are significant at the 5% level.

The bacterial counts, flavor scores, pH values and acidities vary with changes in storage temperatures. Generally, lower storage temperatures gave lower bacterial counts, higher flavor scores, higher pH values and lower acidities. The differences in these values, as affected by the storage temperature, are significant at the 1% level. (Tables I, II, III and IV). The greatest difference occurred between 40° F. and 50° F. The samples stored at 35° F. and 40° F. were almost the same. These points are illustrated in Figures 1, 2, 3 and 4.

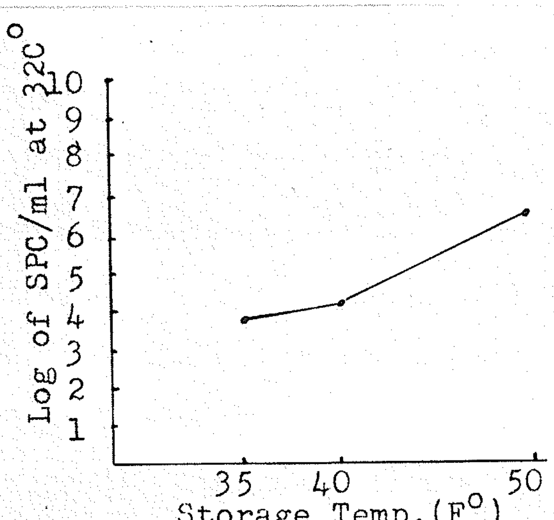

Fig.1 The effect of storage temp. on bacterial count.

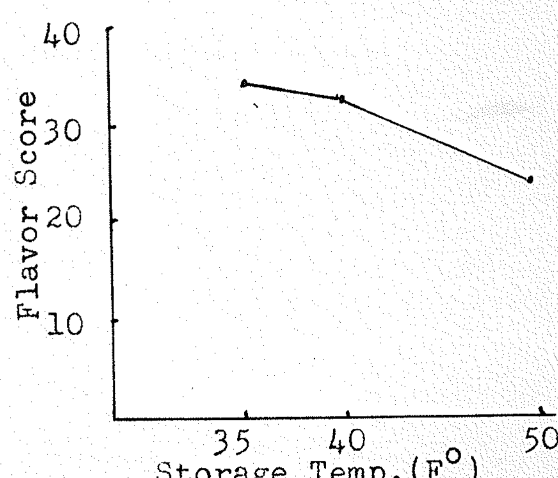

Fig.2 The effect of storage temp. on flavor.

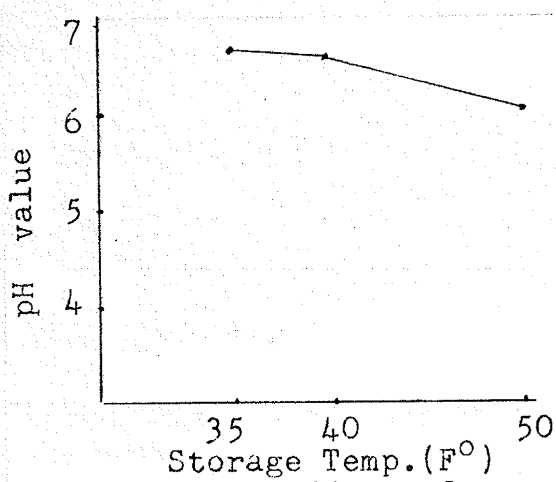

Fig.3 The effect of storage temp. on pH value .

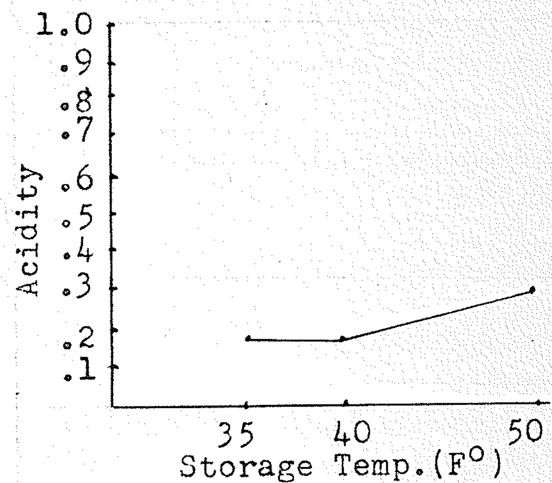

Fig.4 The effect of storage temp. on acidity .

The effect of the storage temperature on the change in the bacterial count was not significantly different between the two methods (Table I). However, the changes in flavor score, pH and acidity were different with the two methods. This difference becomes more significant as the storage temperature increases. (Figures 5, 6 and 7).

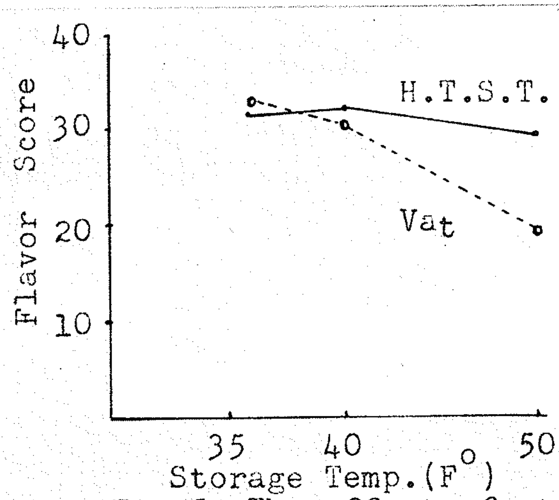

Fig.5 The effect of storage temp.& past. method on flavor .

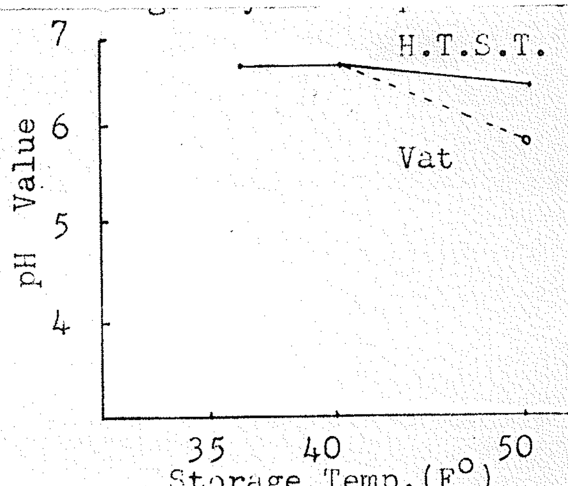

Fig.6 The effect of storage temp. & past. method on pH .

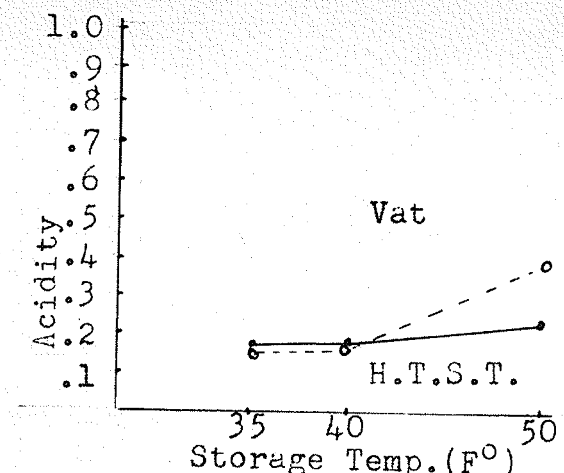

Fig.7 The effect of storage temp.& past.method on acidity .

The bacterial count increases with the number of days in storage. The log phase of growth appears to start about the third day and the rate of multiplication does not slow down until after nine days in storage. (Figure 8).

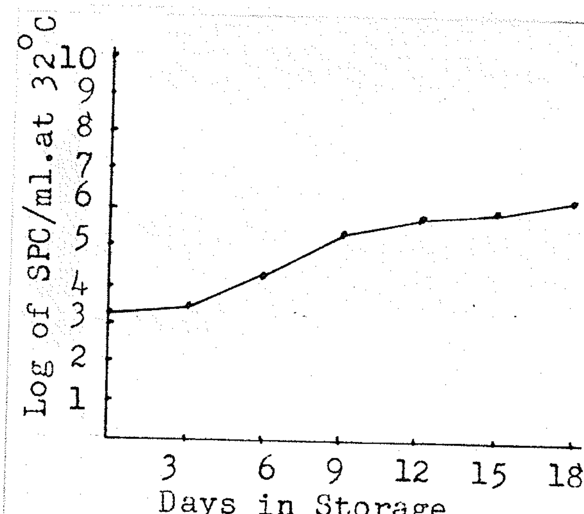

Fig.8 The effect of storage days on bacterial count .

The effect of the number of days in storage on the change in flavor and pH is significant at the 5% level. The flavor scores and pH values decreased with the number of days in storage. The rapid decrease in flavor scores occurs in the first 9 days and the change of pH becomes more significant after 6 days in storage. (Figures 9 and 10).

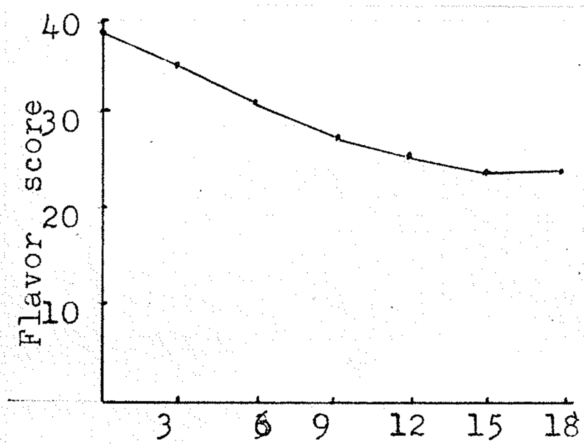

Fig.9 The effect of storage days on flavor.

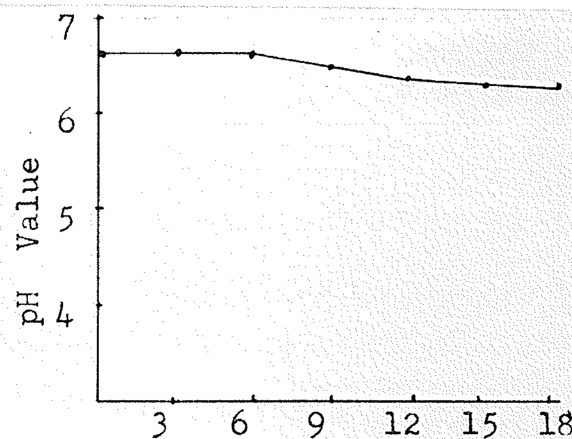

Fig.10 The effect of storage days on pH value.

The increase in the bacterial count after storage was not the same with the two methods of pasteurization. The bacterial count of the vat pasteurized milk increased more rapidly and gave much higher counts than the H.T.S.T. pasteurized milk. (Figure 11). The changes of flavor, pH and acidity are almost the same for the two methods.

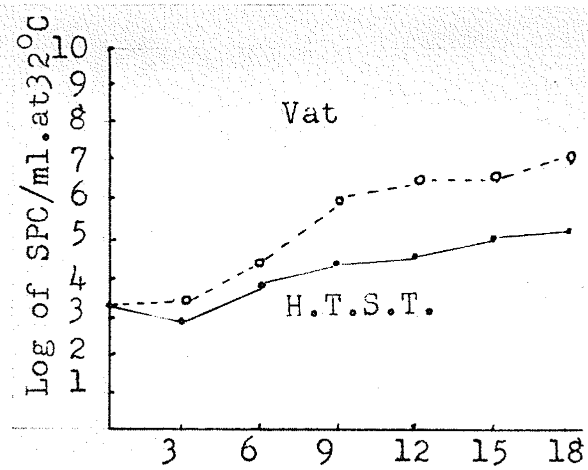

Fig.11 The effect of storage days & past.method on bacterial count .

The effect of temperature on the change of bacterial count, flavor, pH and acidity after various storage days is significant at the 1% level. Higher storage temperatures gave higher bacterial counts, lower flavor scores, lower pH values and higher acidities. The differences become greater as the storage days progress. (Figures 12, 13, 14, and 15).

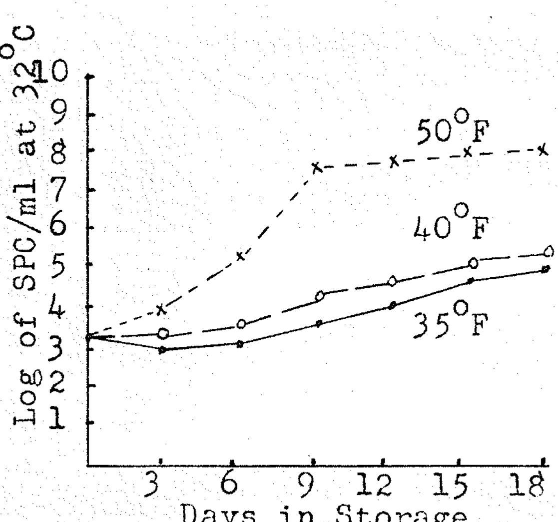

Fig.12 The effect of storage days & temp. on bacterial count .

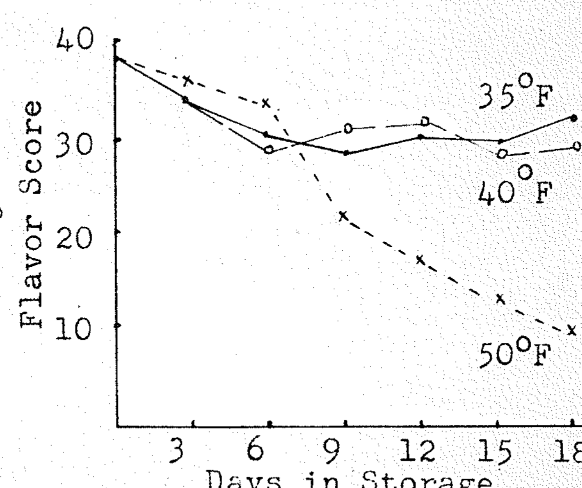

Fig.13 The effect of storage days & temp. on flavor .

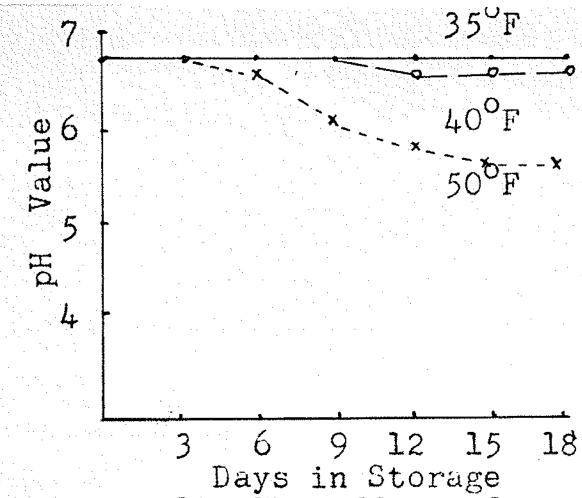

Fig.14 The effect of storage days & temp. on pH .

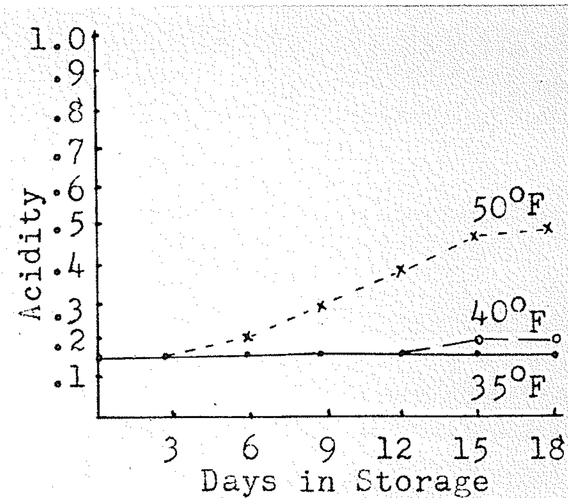

Fig.15 The effect of storage days & temp. on acidity .

The changes in bacterial count, flavor, pH and acidity were not the same for the two methods when the milk was stored for different periods of time at different temperatures. Vat pasteurized milk always gave higher bacteria counts, lower flavor scores, lower pH values and higher acidities. The differences become more significant as the number of days in storage increase. (Figures 16, 17, 18 and 19).

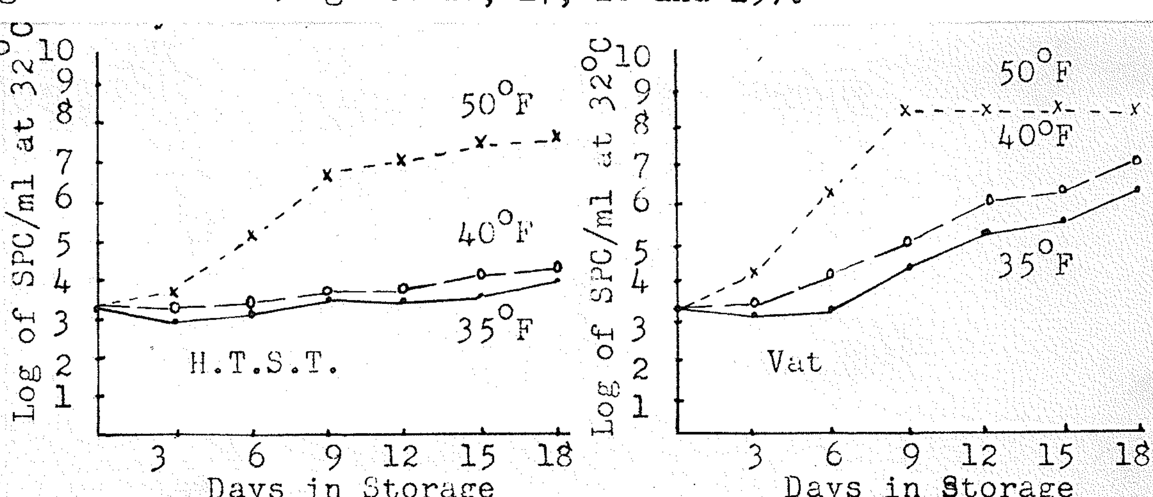

Fig.16 The effect of storage days, storage temp. & past. method on bacterial count .

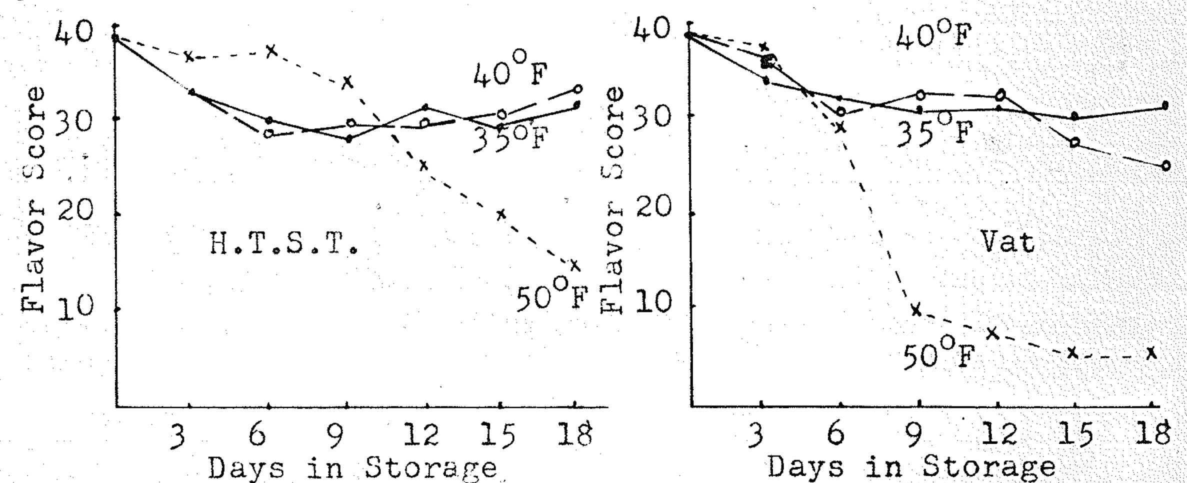

Fig.17 The effect of storage days, storage temperatures and past. method on flavor score .

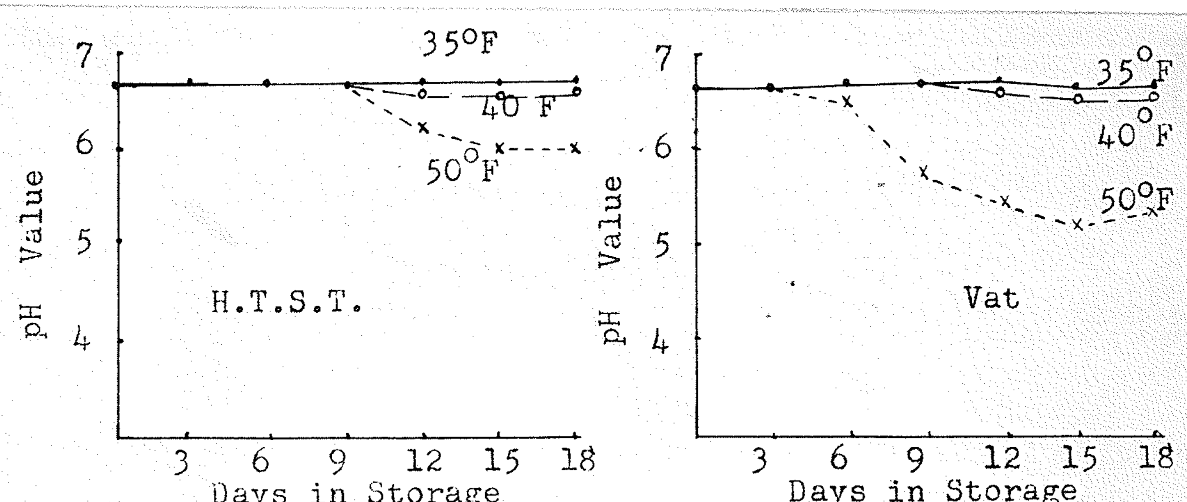

Fig.18 The effect of storage days, storage temperatures and past. method on pH .

Table V. Number of Days Storage Before Coliforms Appeared in V.R.B. Agar.

Trial	Storage Temp. F.	Pasteurization Vat	Pasteurization H.T.S.T.
1	35	6	15
	40	6	15
	50	3	15
2	35	9	-
	40	9	-
	50	15	6 (atypical)
3	35	18	-
	40	18	-
	50	12	-
4	35	-	-
	40	9	-
	50	-	-
5	35	-	-
	40	12	-
	50	15	-
6	35	-	-
	40	-	-
	50	-	-
7	35	-	-
	40	-	-
	50	-	-
8	35	-	-
	40	-	-
	50	-	-

<u>Coliforms</u>: The presence of coliform organisms in freshly pasteurized milk is an indication of contamination after pasteurization. There were no coliform organisms in any of the samples immediately after pasteurization, Table V. However, in certain samples coliforms did appear after a number of days in storage. In sample number 2 atypical whitish colonies appeared after both vat and H.T.S.T. pasteurization.

DISCUSSION

Pasteurization Method.

The method of pasteurization appears to be a very important factor in the keeping quality of milk. The milk pasteurized by the H.T.S.T. method was significantly superior, at the 1% level, in both bacterial count and flavor to the milk pasteurized by the vat method. The difference both in pH and in acidity was significant at the 5% level.

The bacterial counts of the samples pasteurized by the vat method increased during storage and this difference became much greater at the higher storage temperature (50° F.). At 50° F. the H.T.S.T. pasteurized milk had a fairly good flavor score for the first 10 days, however, the flavor score of the vat pasteurized milk decreased rapidly after the third day mainly due to the increase of developed acidity. The flavor scores of the samples stored at 40° F. and 35° F. were quite close. The vat pasteurized seemed to have a slightly better flavor for the first 9 days of storage beyond this period the H.T.S.T. pasteurized milk retained a better flavor. When considering only the milk stored at 35° F. there is little difference in flavor score between the two methods of pasteurization throughout the 18-day storage period.

These results indicate that the milk pasteurized with H.T.S.T. method had better keeping quality, if the proper storage temperature was used. The better keeping quality may be due to the fact that the H.T.S.T. unit is a completely closed system and may eliminate any possibility of contamination during pasteurization. In addition some authors have proved that the H.T.S.T. method destroyed more acid producing bacteria, the cause of the chief flavor defect in the vat pasteurized milk. It would appear that a shift to a different method of pasteurization for reasons of economy of time, space and labor has resulted in the production of a higher quality product.

This statement is not in agreement with those of Hileman (37) who stated that the H.T.S.T. method of pasteurization gave higher bacterial counts than the vat method. However, he used laboratory pasteurization instead of commercial vat pasteurization. Some differences may exist between laboratory pasteurization and commercial pasteurization.

Storage Temperature.

The storage temperature had the most significant effect on the keeping quality of the pasteurized milk. The bacterial count was always higher at the higher temperatures, the acidity was higher and the pH was lower. The greatest difference in storage temperatures was between 50° F. vs 35° - 40° F.

The flavors were much lower at 50° F. over long periods of time. However, up to nine days storage with H.T.S.T. pasteurization and up to three days with vat pasteurization the milk at 50° F. was better in flavor than that at 35° - 40° F. However, after this period of time the flavor dropped off very rapidly and higher acidities and souring resulted. The improvement of flavor with the higher temperature is due to the inhibition of the development of oxidized flavor. This may be due to the lower oxygen retention of the milk at the higher temperatures or to the effect on the EH of the rapid bacterial growth at the higher temperature. It may be wise to store high quality pasteurized milk at a temperature not below 40° F. instead of at lower temperatures. This practise has been recommended by other authors (30). However, the proper storage temperature for a particular quality of pasteurized milk seems to depend on the desired storage period before consumption.

Days in Storage.

The effect of the number of days in storage on the bacterial counts was significant at the 1% level. The effect on the change in flavor and pH was significant at the 5% level and the effect on the change in acidity was not significant. However, in most cases the differences of the second order interactions among the storage days, storage temperatures and pasteurization methods were significant at the 1% level.

Samples of milk pasteurized by the H.T.S.T. method and stored at 35° or 40° F. were still in reasonably good condition even after 18 days storage when the standard used was as follows: Standard plate count/ml not more than 50,000, flavor score not less than 33 and an acidity of not more than 0.19%. Samples of vat pasteurized milk were kept in fairly good condition only under storage at 35° F. If 40° F. was used the samples were good for only nine days.

The chief defect encountered in the samples stored at a low temperature was oxidized flavor. The samples stored at higher temperatures became sour rapidly within a few days. However, there was still some difference between the two pasteurized milks. The H.T.S.T. pasteurized milk always kept in good condition at least three days longer than the vat pasteurized milk.

Coliform.

No coliforms appeared at any time in nine out of the sixteen samples. In the other seven trials coliform organisms were found to be present after various days in storage. Since none were found for at least three days after pasteurization it would appear that the number of organisms present was so small that it took a number of days before they multiplied sufficiently to appear on the plates. Even though no coliform organisms appeared until after 3 days in storage there still may have been coliform organisms present in the pasteurized milk.

The presence of atypical whitish colonies on certain coliform plates would bear further investigation. It may be due to overcrowding on the plates or to a particular species present.

CONCLUSIONS

1. Milk pasteurized by the H.T.S.T. method at 161° F. for 16 seconds yields a product with a lower bacterial count, a higher pH and a higher flavor score than milk pasteurized by the vat method at 143° F. for 30 minutes.
2. The storage temperature has a significant effect on the bacterial count, flavor, pH and acidity of the pasteurized product.
3. High quality raw milk properly pasteurized may be in good condition from the standpoint of bacterial count, flavor, pH and acidity after 18 days storage.
4. The proper storage temperature for pasteurized milk should be determined by the quality of the pasteurized milk and the length of storage desired.

SUMMARY

Experiments have been carried out to determine the effect of the method of pasteurization, the storage temperature and the number of days in storage on the keeping quality of pasteurized milk. Milk obtained from the University dairy was pasteurized by the H.T.S.T. and vat methods and samples were stored at 35° F., 40° F., and 50° F. for a period up to 18 days. Samples were analyzed at three day intervals for bacterial count, flavor, pH and acidity.

Milk pasteurized by the H.T.S.T. method at 161° F. for 16 seconds produced a better product from the standpoint of bacterial count, pH and flavor than milk pasteurized at 143° F. for 30 minutes.

The storage temperature had a significant effect on the bacterial count, pH, acidity and flavor of the pasteurized product. Storage at high temperatures tend to inhibit the development of oxidized flavor. However, storage at 50° F. over a long period of time induced the development of acidity and the souring of milk. Pasteurized milk with a low bacterial count should perhaps be stored at 40° F. rather than at 35° F. Milk with a high bacterial count should be stored at lower temperatures (35° F.). The proper storage temperature seems to be determined by the quality of the pasteurized milk as well as by the length of storage period desired before consumption.

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APPENDIX

Table 1

TRIAL I. SAMPLE PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	39000	32000	-	6.620	0.160	No obj.flav.	40.0
	3	30000	30000	-	6.630	0.170	" " "	40.0
	6	30000	30000	-	6.620	0.165	Oxid.flav.	28.9
	9	53000	55000	-	6.630	0.165	" "	28.9
	12	2.4m.	3.5m.	TNC	6.700	0.170	Normal	40.0
	15	32.0m.	41.0m.	24000	6.800	0.170	Stale,lack.flv.	38.4
	18	300.0m.	300.0m.	3m.	6.600	0.170	Stale,not bad	38.4
40°F	0	39000	32000	-	6.620	0.160	No obj.flav.	40.0
	3	32000	32000	-	6.650	0.160	" " "	40.0
	6	30000	30000	-	6.660	0.160	Oxid.flav.	28.9
	9	300000	300000	-	6.700	0.160	" "	28.9
	12	60000	630000	-	6.690	0.160	Slig.met.flv.	35.5
	15	320m.	250m.	TNC	6.150	0.175	Uncl.very stale	26.9
	18	300m.	300m.	30m.	6.490	0.170	Bit.slig.uncl .	25.2
50°F	0	39000	32000	-	6.620	0.160	No obj.flv.	40.0
	3	94000	90000	-	6.630	0.170	" " "	40.0
	6	1.9m.	2.3m.	-	6.670	0.170	Normal	40.0
	9	57.0m.	190.00m.	-	6.450	0.200	Bitterness	30.7
	12	700.0m.	900.0m.	-	4.990	0.550	Sour	00.0
	15	750.0m.	850.0m.	65m.	4.990	0.560	Yeasty, sour	00.0
	18	300.0m.	560.0m.	30m.	4.250	0.740	Sour, putrify	00.0

Table 2

TRIAL I. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	43000	23000	-	6.61	0.160	No obj.flav.	40.0
	3	31000	21000	3	6.68	0.160	" " "	40.0
	6	30000	30000	too num.	6.70	0.160	Oxid.flav.	28.9
	9	1.2m.	3.1m.	" "	6.70	0.160	" & stale flav.	28.9
	12	44.0m.	49.0m.	530000	6.63	0.160	Stale & old flav.	38.4
	15	58.0m.	95.0m.	15m.	6.55	0.170	Stale	38.4
	18	300.0m.	300.0m.	28m.	6.40	0.210	"	38.4
40°F	0	43000	23000	-	6.61	0.160	No obj.flav.	40.0
	3	40000	29000	7	6.69	0.160	" " "	40.0
	6	180000	310000	too num.	6.69	0.160	Oxid.flav.	28.9
	9	15.0m.	33.0m.	" "	6.68	0.165	" "	28.9
	12	75.0m.	95.0m.	500000	6.45	0.170	Slig.sour & bitter	25.2
	15	80.0m.	190.0m.	too num.	6.35	0.210	Slig.stale & bitter	30.7
	18	850.0m.	650.0m.	150m.	6.10	0.290	Strong bit.slig.uncl.	21.6
50°F	0	43000	23000	-	6.61	0.160	No obj.flav.	40.0
	3	400000	520000	too num.	6.68	0.160	" " "	40.0
	6	5.0m.	6.0m.	too num.	6.50	0.190	Oxid.flav.	28.9
	9	1100.0m.	900.0m.	too num.	5.35	0.530	Sour	00.0
	12	2000.0m.	2900.0m.	16m.	4.90	0.710	Coag.& sour	00.0
	15	3000.0m.	3000.0m.	30m.	4.62	0.720	" " "	00.0
	18	430.0m.	700.0m.	30m.	4.52	0.740	Sour,coag.,proteolysis	00.0

Table 3

TRIAL II. SAMPLE PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	16000	11000	-	6.68	0.160	No obj.flav.	40.0
	3	17000	18000	-	6.68	0.160	Slig. feedy	38.8
	6	15000	19000	-	6.62	0.160	Oxidized flav.	28.9
	9	300000	300000	-	6.59	0.160	Pron.oxid.flav.	21.6
	12	300000	300000	-	6.68	0.160	" " "	21.6
	15	300000	300000	-	6.68	0.160	" " "	21.6
	18	30000	30000	-	6.70	0.170	Strong oxid.flav.	21.6
40°F	0	16000	11000	-	6.68	0.160	No obj.flav.	40.0
	3	17000	20000	-	6.62	0.160	Slig.oxid.flav.	35.5
	6	30000	30000	-	6.62	0.160	Oxidized flav.	28.9
	9	300000	300000	-	6.59	0.160	Slig.oxid.	35.5
	12	300000	300000	-	6.69	0.160	Oxidized flav.	28.9
	15	300000	300000	-	6.70	0.170	" "	28.9
	18	9000	9000	-	6.80	0.170	" "	28.9
50°F	0	16000	11000	-	6.68	0.160	No obj.flav.	40.0
	3	26000	27000	-	6.58	0.160	Slig.feedy	38.8
	6	34m.	85m.	-	6.56	0.160	Slig. bitter	35.6
	9	160m.	180m.	-	6.45	0.180	Strong bitter	25.2
	12	2900m.	4600m.	-	4.70	0.620	Coag.sour & putr.	00.0
	15	1300m.	1200m.	-	4.80	0.610	Coag.stale & sour	00.0
	18	1800m.	1900m.	-	4.65	0.710	Yeasty sour & bit.	00.0

Table 4

TRIAL III. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	21000	19000	-	6.68	0.160	No obj.flav.	40.0
	3	25000	25000	-	6.58	0.160	Slig.oxid.	35.5
	6	25000	21000	-	6.65	0.160	Oxid.flav.	28.9
	9	320000	440000	300	6.58	0.160	" "	38.4
	12	3m.	3.8m.	450	6.67	0.160	Oxid.& slig.stale	28.9
	15	2.4m.	8.9m.	-	6.62	0.170	Oxid.stale & uncl.	21.6
	18	12.0m.	32.0m.	17000	6.80	0.170	" " "	21.6
40°F	0	21000	19000	-	6.68	0.160	No obj.flav.	40.0
	3	29000	30000	-	6.58	0.160	Slig.feedy flav.	38.8
	6	30000	30000	-	6.68	0.160	Strong oxid.	21.6
	9	3m.	3m.	-	6.60	0.160	Oxidized	28.9
	12	4.5m.	5m.	-	6.62	0.160	Slig.oxid.	35.5
	15	3.6m.	24m.	-	6.60	0.170	Oxidized	28.9
	18	8.3m.	28m.	-	6.80	0.170	"	28.9
50°F	0	21000	19000	-	6.68	0.160	No obj. flav.	40.0
	3	195000	250000	200	6.58	0.160	" " "	40.0
	6	170m.	170m.	-	6.70	0.230	Stale going sour	21.6
	9	1100m.	1500m.	-	5.00	0.500	Coag.,slig.bit.	00.0
	12	600m.	1000m.	-	4.98	0.660	Coag.sour,putr.	00.0
	15	300m.	450m.	4m.	4.80	0.730	" " "	00.0
	18	82m.	140m.	600000	4.70	0.740	" " "	00.0

Table 5

TRIAL III. SAMPLES PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	16000	12000	-	6.68	0.155	No obj.flav.	40.0
	3	12000	12000	-	6.68	0.160	Oxid.flav.	28.9
	6	15000	16000	-	6.80	0.160	Slig.oxid.flav.	35.5
	9	30000	30000	-	6.70	0.160	Pron.oxid.flav.	21.6
	12	30000	30000	-	6.75	0.160	Little feedy	38.8
	15	11000	12000	-	6.72	0.160	Oxid.(distinct)	28.9
	18	12000	12000	-	6.78	0.160	Strong oxid.	21.6
40°F	0	16000	12000	-	6.68	0.155	No obj.flav.	40.0
	3	11000	13000	-	6.72	0.160	Oxid.flav.	28.9
	6	16000	17000	-	6.82	0.160	Slig.oxid.flav.	35.5
	9	30000	30000	-	6.70	0.160	Oxidized	28.9
	12	30000	30000	-	6.70	0.160	"	28.9
	15	30000	30000	-	6.75	0.160	"	28.9
	18	10000	12000	-	6.80	0.160	"	28.9
50°F	0	16000	12000	-	6.68	0.155	No obj.flav.	40.0
	3	12000	15000	-	6.62	0.160	Slig.oxid.	35.5
	6	300000	300000	-	6.72	0.160	Not bad	40.0
	9	3m.	3m.	-	6.68	0.170	Slig.oxid.	35.5
	12	3m.	3m.	-	6.62	0.170	" "	35.5
	15	9.7m.	10m.	-	6.70	0.170	Slig.oxid. & uncl.	29.1
	18	3m.	3m.	-	6.70	0.170	Oxidized	28.9

Table 6

TRIAL III. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	21000	19000	-	6.61	0.150	No obj.flav.	40.0
	3	11000	12000	-	6.68	0.155	Oxidized	28.9
	6	14000	19000	-	6.78	0.160	Pron.oxid.	21.6
	9	30000	30000	-	6.70	0.160	" "	21.6
	12	300000	300000	-	6.68	0.160	Oxidized	28.9
	15	300000	300000	-	6.70	0.160	"	28.9
	18	41m.	61m.	3.2m.	6.78	0.160	Slig.oxid.cappy	35.5
40°F	0	21000	19000	-	6.61	0.150	No obj.flav.	40.0
	3	10000	12000	-	6.68	0.155	Very slig.oxid.	35.5
	6	30000	30000	-	6.80	0.160	Oxidized	28.9
	9	300000	300000	7	6.70	0.160	Oxid.stale	26.9
	12	300000	420000	-	6.70	0.160	Slig.oxid.	35.5
	15	300000	13m.	-	6.68	0.160	" " & stale	33.5
	18	23m.	30m.	170000	6.70	0.160	Metalic	28.9
50°F	0	21000	19000	-	6.61	0.150	No obj.flav.	40.0
	3	12000	10000	-	6.63	0.160	Oxidized	28.9
	6	4700000	6400000	-	6.70	0.150	very slig.oxid.	35.5
	9	1500m.	1200m.	-	5.93	0.300	Part.coag.sour	00.0
	12	2300m.	2040m.	6m.	4.92	0.520	Sour,coag.metalic	00.0
	15	2900m.	2800m.	32m.	4.71	0.610	Sour,coag.putr.	00.0
	18	320m.	300m.	14m.	6.05	0.350	Coag.sour & bit.	00.0

Table 7

TRIAL IV. SAMPLE PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	300	300	-	6.82	0.170	No obj.flav.	40.0
	3	300	300	-	6.75	0.170	Slig.oxid.	35.5
	6	300	300	-	6.75	0.170	Slig.stale	39.5
	9	300	300	-	6.72	0.170	A little stale	39.5
	12	300	17000	-	6.80	0.170	Stale	38.4
	15	300	300	-	6.75	0.170	Oxid. & stale	26.9
	18	850	1200	-	6.75	0.170	Stale & bitter	28.7
40°F	0	300	300	-	6.82	0.170	No obj.flav.	40.0
	3	300	300	-	6.75	0.170	Slig.oxid.	35.5
	6	300	300	-	6.72	0.170	Oxid.	28.9
	9	300	300	-	6.78	0.170	Slig.oxid.	35.5
	12	7700	37000	-	6.78	0.170	Oxid.	28.9
	15	12000	33000	-	6.70	0.170	Stale	38.4
	18	10000	47000	-	6.80	0.170	Stale	38.4
50°F	0	300	300	-	6.82	0.170	No obj.flav.	40.0
	3	890	3800	-	6.70	0.170	Normal	40.0
	6	47000	90000	-	6.75	0.170	Very slig. stale	39.5
	9	840000	850000	-	6.72	0.170	Slig. stale	39.5
	12	540000	1m.	-	6.75	0.170	Oxid. & stale	26.9
	15	1.9m.	2.7m.	-	6.62	0.170	Slig.oxid.uncl.	30.5
	18	370m.	280.0m.	-	6.15	0.280	Sour & uncl.	00.0

Table 8

TRIAL IV. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	280	330	-	6.82	0.170	No obj.flav.	40.0
	3	450	390	-	6.70	0.160	Normal	40.0
	6	570	610	-	6.72	0.160	Very slig.oxid.	35.5
	9	75000	81000	-	6.73	0.160	" " "	35.5
	12	2.0m.	3.8m.	-	6.78	0.160	Pron.oxid.	21.6
	15	2.7m.	5.0m.	-	6.70	0.160	Oxid. & stale	26.9
	18	2.3m.	27.0m.	-	6.68	0.160	Stale & uncl.	28.4
40°F	0	280	330	-	6.82	0.170	No obj.flav.	40.0
	3	390	490	-	6.75	0.160	Slig.oxid.	35.5
	6	140000	170000	-	6.75	0.160	Not oxid. normal	40.0
	9	490000	3.8m.	180000	6.78	0.160	" " "	40.0
	12	3.0m.	47.0m.	-	6.78	0.160	Stale	38.4
	15	52.0m.	170.0m.	23m.	6.52	0.190	Uncl.strong sour	10.0
	18	30.0m.	43.0m.	-	6.70	0.170	Stale & uncl.	28.4
50°F	0	280	330	-	6.82	0.170	No obj.flav.	40.0
	3	1000	1000	-	6.70	0.160	Slig.oxid.	35.5
	6	4.0m.	4.7m.	-	6.78	0.160	Strong oxid.	35.5
	9	200.0m.	270.0m.	-	6.48	0.210	Slig.oxid. sour	21.9
	12	80.0m.	87.0m.	-	6.70	0.170	Uncl.	29.1
	15	300.0m.	580.0m.	-	6.10	0.350	Uncl. sour	11.6
	18	680.0m.	520.0m.	-	6.10	0.340	" "	11.6

Table 9

TRIAL V. SAMPLE PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	300	300	-	6.70	0.170	No obj.flav.	40.0
	3	300	300	-	6.70	0.170	" " "	40.0
	6	300	300	-	6.69	0.170	Pron.oxid.	21.6
	9	300	300	-	6.70	0.170	Oxid. & stale	26.9
	12	300	300	-	6.75	0.170	Slig.oxid.stale	33.5
	15	300	280	-	6.70	0.170	" " "	33.5
	18	6500	10000	-	6.68	0.170	Stale	38.4
40°F	0	300	300	-	6.70	0.170	No obj.flav.	40.0
	3	460	470	-	6.70	0.170	Oxidized	28.9
	6	3000	3000	-	6.68	0.170	Oxid. & stale	26.9
	9	300	300	-	6.70	0.170	Oxid.	28.9
	12	2000	4000	-	6.75	0.170	Slig.oxid.stale	33.5
	15	3000	50000	-	6.60	0.175	" " "	33.5
	18	32000	44000	-	6.60	0.170	Slig.stale	39.5
50°F	0	300	300	-	6.70	0.170	No obj.flav.	40.0
	3	300	420	-	6.68	0.170	Slig.oxid.	35.5
	6	380000	390000	-	6.62	0.170	Slig.stale	39.5
	9	42m.	49m.	-	6.62	0.180	" "	39.5
	12	30m.	30m.	-	6.62	0.190	Unclean	29.1
	15	3m.	3m.	-	6.50	0.190	"	29.1
	18	35m.	35m.	-	6.40	0.210	Very uncl.	22.6

Table 10

TRIAL V. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	300	300	-	6.70	0.160	No obj.flav.	40.0
	3	300	300	-	6.70	0.160	Slig.oxid.	35.5
	6	1100	1300	-	6.70	0.160	" "	35.5
	9	64000	100000	-	6.70	0.160	" "	28.9
	12	1.42m.	4.5m.	-	6.75	0.160	Oxid.	28.9
	15	3.60m.	12.0m.	-	6.65	0.160	Oxid.	28.9
	18	3.00m.	32.0m.	-	6.65	0.160	Slig.oxid.	35.5
40°F	0	300	300	-	6.70	0.160	No obj.flav.	40.0
	3	500	690	-	6.70	0.160	Oxid.	28.9
	6	76000	170000	-	6.70	0.160	Oxid.	28.9
	9	4.4m.	7.5m.	-	6.72	0.160	Slig.stale,oxid.	26.9
	12	13.0m.	39.0m.	-	6.72	0.160	Slig.oxid.uncl.	30.5
	15	29.0m.	110.0m.	-	6.60	0.180	Very uncl.	22.6
	18	65.0m.	100.0m.	-	6.60	0.170	Uncl. & sour	16.9
50°F	0	300	300	-	6.70	0.160	No obj.flav.	40.0
	3	16000	22000	-	6.70	0.160	Slig.oxid.	35.5
	6	440000	30m.	-	6.70	0.160	Slig.oxid.stale	34.5
	9	270m.	2800m.	-	5.05	0.560	Sour uncl. coag.	00.0
	12	2000m.	2300m.	-	4.90	0.700	" " "	00.0
	15	1600m.	2600m.	1.8m.	4.95	0.730	" " "	00.0
	18	3200m.	3000m.	-	4.80	0.790	" " "	00.0

Table 11

TRIAL VI. SAMPLE PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	300	300	-	6.60	0.170	No obj. flav.	40.0
	3	300	300	-	6.70	0.170	Pron.oxid.bit.	21.6
	6	300	300	-	6.70	0.170	Oxid. & stale	26.9
	9	300	300	-	6.70	0.170	Oxid.	28.9
	12	300	300	-	6.70	0.170	Oxid.	28.9
	15	300	300	-	6.70	0.170	Slig.pron.oxid.	21.5
	18	300	300	-	6.70	0.170	Slig.oxid.stale	33.5
40°F	0	300	300	-	6.60	0.170	No obj.flav.	40.0
	3	300	300	-	6.70	0.170	Oxid.	28.9
	6	300	300	-	6.70	0.170	"	28.9
	9	300	300	-	6.70	0.170	"	28.9
	12	640	800	-	6.70	0.170	"	28.9
	15	300	13000	-	6.65	0.170	"	28.9
	18	300	300	-	6.68	0.170	Stale,Uncl.	27.1
50°F	0	300	300	-	6.60	0.170	No obj.flav.	40.0
	3	300	300	-	6.75	0.160	Oxid.	28.9
	6	8400	8500	-	6.70	0.170	Slig.oxid.	35.5
	9	420000	470000	-	6.65	0.170	Slig.stale	39.5
	12	320000	280000	-	6.70	0.170	Slig.stale	39.5
	15	280m.	350m.	-	5.70	0.460	Sour & uncl.	11.1
	18	30m.	30m.	-	6.35	0.220	Yeasty & uncl.	11.1

Table 12

TRIAL VI. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	400	670	-	6.60	0.160	No obj.flav.	40.0
	3	370	460	-	6.70	0.160	Pron.oxid.	21.6
	6	650	600	-	6.70	0.160	Slig.oxid.stale	33.5
	9	1000	1400	-	6.68	0.160	Oxid. stale	26.9
	12	4300	13000	-	6.70	0.160	" "	26.9
	15	330000	700000	-	6.70	0.160	Slig.oxid.stale	33.5
	18	250000	4.8m.	-	6.75	0.160	Oxid. stale	26.9
40°F	0	400	670	-	6.60	0.160	No obj.flav.	40.0
	3	1200	1300	-	6.70	0.160	Oxidized	28.9
	6	8500	82000	-	6.70	0.160	Slig.oxid.stale	33.5
	9	300000	2.7m.	-	6.65	0.160	" " "	33.5
	12	2.5m.	38.0m.	-	6.70	0.160	" " "	33.5
	15	3.7m.	66.0m.	-	6.60	0.180	Very uncl.	22.6
	18	37.0m.	200.0m.	-	6.65	0.180	" "	22.6
50°F	0	400	670	-	6.60	0.160	No obj.flav.	40.0
	3	380000	870000	-	6.70	0.160	Oxidized flav.	28.9
	6	30m.	30m.	-	5.50	0.410	Sour & uncl.	11.6
	9	2500m.	3300m.	-	4.95	0.640	Sour uncl. & coag.	00.0
	12	2000m.	2800m.	-	4.95	0.670	" " "	00.0
	15	1600m.	1900m.	-	4.80	0.750	" " "	00.0
	18	970m.	2200m.	-	4.80	0.760	" " "	00.0

Table 13

TRIAL VII. SAMPLE PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	300	300	-	6.65	0.170	No obj.flav.	40.0
	3	300	300	-	6.70	0.170	" " "	40.0
	6	300	300	-	6.68	0.170	Oxid.flav.	28.9
	9	300	300	-	6.65	0.170	" "	28.9
	12	300	300	-	6.68	0.170	" "	28.9
	15	300	300	-	6.70	0.170	Slig.oxid.& stale	34.5
	18	300	800	-	6.70	0.170	Slig.stale	39.5
40°F	0	300	300	-	6.65	0.170	No obj.flav.	40.0
	3	300	300	-	6.70	0.170	" " "	40.0
	6	300	300	-	6.70	0.170	Oxid.flav.	28.9
	9	300	300	-	6.68	0.170	" "	28.9
	12	300	1600	-	6.70	0.170	" "	28.9
	15	300	300	-	6.70	0.170	Slig.oxid.& stale	33.5
	18	2100	2900	-	6.70	0.170	Slig.stale	39.5
50°F	0	300	300	-	6.65	0.170	No obj.flav.	40.0
	3	300	300	-	6.70	0.170	" " "	40.0
	6	27000	50000	-	6.70	0.170	Slig.oxid.	35.5
	9	12m.	20m.	-	6.62	0.180	Very slig.sour,bit.	28.5
	12	30m.	30m.	-	6.62	0.180	Little bit.stale	33.5
	15	9m.	12m.	-	6.52	0.200	Yeasty & uncl.	22.6
	18	3m.	3m.	-	6.60	0.180	Slig.sour & stale	31.3

Table 14

TRIAL VII. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	260	400	-	6.65	0.160	No obj.flav.	40.0
	3	320	330	-	6.70	0.160	" " "	40.0
	6	310	300	-	6.70	0.160	Slig.oxid.stale	33.5
	9	300	300	-	6.70	0.160	Oxidized	28.9
	12	300	300	-	6.72	0.160	A little oxid.	35.5
	15	300	300	-	6.70	0.160	Very slig.oxid.	35.5
	18	300	300	-	6.70	0.160	Slig.stale	39.5
40°F	0	260	400	-	6.65	0.160	No obj.flav.	40.0
	3	340	300	-	6.72	0.160	" " "	40.0
	6	300	300	-	6.70	0.160	Slig.oxid.stale	33.5
	9	320	300	-	6.70	0.160	" "	33.5
	12	420	1000	-	6.70	0.160	Oxidized	28.9
	15	760	2500	-	6.70	0.160	Very slig.stale	39.5
	18	3200	25000	-	6.70	0.160	Stale	38.4
50°F	0	260	400	-	6.65	0.160	No obj.flav	40.0
	3	3000	3000	-	6.72	0.160	" " "	40.0
	6	3000	3000	-	6.70	0.160	Very slig.oxid.	35.5
	9	120000	110000	-	6.65	0.160	No obj.& oxid.	40.0
	12	340000	350000	-	6.65	0.160	No obj.flav.	40.0
	15	2.3m.	3m.	-	6.60	0.160	Stale	38.4
	18	8.3m.	7m.	-	6.55	0.180	Very stale	36.6

Table 15

TRIAL VIII. SAMPLE PASTEURIZED WITH H.T.S.T. METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	700	650	-	6.60	0.160	Slig.oxid.flav.	35.5
	3	610	530	-	6.67	0.160	Pron.oxid.flav.	21.6
	6	660	600	-	6.70	0.160	Oxid.flav.	28.9
	9	610	300	-	6.68	0.160	" "	28.9
	12	300	380	-	6.72	0.160	Pron.flav.	21.6
	15	330	320	-	6.68	0.160	Oxid.flav.	28.9
	18	300	300	-	6.68	0.160	Stale	38.4
40°F	0	700	650	-	6.60	0.160	Slig.oxid.flav.	35.5
	3	580	530	-	6.65	0.160	Oxid.flav.	28.9
	6	500	500	-	6.68	0.160	Oxidized	28.9
	9	490	330	-	6.68	0.160	Oxid.flav.& stale	26.9
	12	400	700	-	6.72	0.160	Oxid.flav.	28.9
	15	1200	3500	-	6.70	0.160	Oxidized	28.9
	18	300	800	-	6.62	0.170	Slig.stale flav.	39.5
50°F	0	700	650	-	6.60	0.160	Slig.oxid.	35.5
	3	590	580	-	6.63	0.160	" "	35.5
	6	5000	16000	-	6.65	0.160	" "	35.5
	9	200000	250000	-	6.65	0.160	Slig.stale	35.5
	12	300000	360000	-	6.68	0.160	No obj.flav.	40.0
	15	2.9m.	2.6m.	-	6.60	0.170	Slig.stale	39.5
	18	12.0m.	37.0m.	-	6.51	0.190	Bitter & stale	28.7

Table 16

TRIAL VIII. SAMPLE PASTEURIZED WITH VAT METHOD

Samples stored at	Storage days	SPC/ml. at 32°C	SPC/ml. at 25°C	Coliform count/ml.	PH Value	Acidity %	Flavor	Score
35°F	0	300	300	-	6.65	0.155	Oxid.flav.	28.9
	3	300	300	-	6.70	0.150	No obj.flav.	40.0
	6	300	300	-	6.70	0.150	Very slig.oxid.	35.5
	9	300	300	-	6.70	0.150	Slig.stale	39.5
	12	750	1100	-	6.80	0.150	Pron.stale	36.6
	15	800	1800	-	6.70	0.150	Uncl.	29.1
	18	450000	490000	-	6.70	0.150	Stale & slig.oxid.	33.5
40°F	0	300	300	-	6.65	0.155	Oxid.flav.	28.9
	3	300	300	-	6.70	0.150	Very slig.oxid.	35.5
	6	300	300	-	6.70	0.150	" " "	35.5
	9	100000	100000	-	6.70	0.150	Slig.stale	39.5
	12	2.5m.	3.1m.	-	6.80	0.150	Slig.oxid.	35.5
	15	2.0m.	4.0m.	-	6.72	0.150	Uncl.	29.1
	18	10.0m.	17.0m.	-	6.70	0.150	Oxid.uncl.	18.9
50°F	0	300	300	-	6.65	0.155	Oxid.flav.	28.9
	3	4000	9000	-	6.70	0.150	No obj.flav.	40.0
	6	2.8m.	4.0m.	-	6.65	0.150	" " "	40.0
	9	210.0m.	200.0m.	-	6.40	0.220	Sour flav.	21.6
	12	1400.0m.	1400.0m.	-	5.35	0.520	Sour flav.	00.0
	15	590.0m.	450.0m.	-	4.75	0.630	" "	00.0
	18	1500.0m.	1900.0m.	-	4.90	0.640	Sour & uncl.	00.0