THESIS

VISIBLE QUALITY OF MARKET MILK AS AFFECTED BY CLARIFICATION AND PASTEURIZATION

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Introduction.

Like bread and water, milk is a well-nigh universal food throughout civilized lands. Moreover, containing, as is shown by chemical analysis, certain solids indispensable in animal food in forms that are easily and readily digested and assimilated, it is one of the most economical as well as one of the most important and valuable means of sustenance. Investigation shows that when milk is purchased at two dollars per hundred pounds, the actual cost of a pound of edible solids is only 15.7 cents; while the cost of a pound of edible solids in beef, with beef at ten dollars and a half ($10.50) per hundred pounds, is 34.3 cents. (The above is a comparison of the retail cost of milk with the cost of hind-quarter beef when purchased by the carcass). Again, one quart of milk supplies practically as much of both protein and energy as three-quarters of a pound of beef of average composition, or of eight average sized eggs, and can usually be procured, as suggested above, for considerably less money. Since, therefore, milk is so economical and valuable a food supply for the masses and since pure milk is so vitally connected with public health, the question of an unadulterated supply of this necessity is an important and pressing one.

Although as yet this problem has not been entirely solved, a number of its phases have been definitely settled. In the first place we may safely state that cheap milk is apt to be poor milk and that an improvement in its quality must inevitably mean an increase in price. In the second place, it will be generally admitted that the conditions under which milk reaches our large cities vary greatly with circumstances. This variation was especially noticeable fifteen to twenty years ago when, though not transported so far as it is today, yet due to imperfection of handling and other carelessness on the part of the farmers, the milk supply was upon the whole of a decidedly inferior quality. Due to regulation initiated and practiced during the past ten years, however, conditions as regards both quality and quantity have noticeably improved. Today it is recognized that the greater part of the dirt and bacterial contamination that used to characterize the marketed milk is external to the cow. Admitting that a small percentage of this contamination comes directly out of the cow's udder and is thus unavoidable, yet cleaner barns, cleaner cows, sterilized and covered pails and, above all, cleanner milkers and a proper cooling of milk immediately after it is drawn, have worked wonders in solving this problem of a pure milk supply.

Naturally the rigid enforcement of the above sug-

gestions is a slow process as well as a difficult one. If stringent laws were at once enacted and put into operation in many cities there would be a consequent milk famine. Again, the practicing of the above suggestions would inevitably so enhance the price of milk as to render it prohibitive to the masses in the large cities. Hence, it is obvious that such improvement may be by evolution rather than by revolution; it must be stimulated and fostered by education and an enlightened public sentiment and, incidentally, by paying the producer a higher price for his product. Until this desired goal is reached however, we shall be obliged to tolerate a milk supply of a less than perfect degree of sanitation. How to improve this milk of a doubtful quality and to overcome its dangerous tendencies during this transition stage, it is here recommended that all milk be properly clarified and pasteurized. Since the process of pasteurization is not an expensive one, (costs about 35 ¢ per 100 lbs. milk) pasteurized milk can be sold to the consumer at a reasonable price, and will be practically as sanitary and hygienic as certified milk.

That pasteurization is annually being adopted by more and more cities and dealers is a strong point in favor of this grade of milk. Only 5% of New York's milk supply

was pasteurized in 1900, while in 1909 the percentage had increased to 25 and today one is safe in affirming that at least 33 1/3% undergoes pasteurization. In Boston and in Chicago 50%, and in Milwaukee approximately 75% of the total milk supply undergoes pasteurization before reaching the ultimate consumer. Hence to provide a more sanitary milk supply without a great increase in cost until certified milk is a practicable possibility, the clarifier and pasteurizer have been designed, the first to eliminate the visible dirt or sediment, and the second to render the bacteria less active and to kill the pathogenic bacteria entirely. It is very necessary, however, that this clarification and pasteurization be properly done. To insure this, therefore, it is indispensable that all clarifying and pasteurizing plants be frequently and carefully inspected by competent authorities.

How Milk is Handled in Milk Plant in the M. A. C. Dairy.

Each morning the milk produced that morning and on the previous evening as well as on the neighboring farms is brought bright and early to the M. A. C. dairy. Here, before it passes through the double ply of fine cloth, or strainer, into the receiving vat, each can is carefully weighed and sampled. From this receiving vat it is pumped into the heater where it is heated to the desired temperature. From here it is conveyed by means of pipes and troughs to the clarifier, where those impurities that were so fine as to be able to pass through the double ply of fine cloth are removed. From this clarifier it next passes into the pasteurizer and is pasteurized immediately. The surplus milk, that is, milk not required for the dairy's customers is separated by means of centrifugal cream separators (DeLaval No. 60 with capacity of 4000 pounds per hour is here used). This systematic arrangement of machinery used for clarification, pasteurization, and separation, respectively, is illustrated by the accompanying diagram:

Clarification.

The milk clarifier resembles the separator in appearance but differs from it in results produced. While the separator divides the whole milk into cream and skim milk, each escaping through its own spout, the clarifier, on theother hand,

delivers the whole milk through the one spout. Its function is to remove not only the insoluble dirt or sediment particles which externally enter while the milk is being drawn or afterwards, but also the internal contaminations consisting of broken-down udder tissues or pus corpuscles, which are invariably to be found in all milk, sometimes even to the extent of a million or more to the cubic centimeter. This dirt collects on the inside of the bowl-shell and should be removed immediately after the process of clarifying is completed.

From the hygienic standpoint the removal of this organic matter is especially important. Otherwise, were it left in the milk, it would be the source of organisms which are likely to cause trouble. This is the case because the presence of such dirt means bacterial infection, which in many cases is decidedly dangerous. It will unquestionably be admitted that milk which containes a large amount of dirt and consequently a large number of bacteria will be far inferior in quality. So decided an improvement over the now old-fashioned milk filter, which never did prove satisfactory, is this modern clarifier doing its work by centrifugal force, that it is today being adopted more and more by city milk-supply plants.

T E S T .

(In the following investigation the DeLaval Centrifugal Milk Clarifier, No. 110, Capacity 4000 pounds per hour, was used).

The milk to be treated was first pumped into the heater from the receiving vat and was heated to a temperature of from 70° to 80° F. It was next conducted to the clarifier through an elbow pipe and open faucet in the regulating cover of this machine and thus entered the bowl. Here it was clarified by the application of the principle of centrifugal force, and passed on through a spout to the pasteurizer. (It should here be mentioned that the machine should reach a uniform speed of 600 revolutions a minute before the milk is allowed to enter and that the inflow be kept uniform; otherwise an irregular rate of speed or even of inflow would result in unsatisfactory clarification).

Results of Test.

Samples of this clarified milk when tested by the sediment tester, i, e., when strained through a cotton disc are usually highly satisfactory. Very occasionally, however, some slight particles of dirt are noticeable on this cotton disc. These particles, however, are probably due to contamination from external sources after the process of clarification has been completed. Again, light flaky, staff-like chaff, or something similar to chaff, very infrequently is

found by testing in the milk after clarification has taken place. This contamination escapes removal from the milk probably because of its extreme lightness in weight in comparison with its surface area, thus buoying it up and consequently enabling it to enter into the outflow of clarified milk.

As shown by the records in Table I, out of 153 sediment-samples of each day's original or raw milk, 8 samples (5.23%) were found to be nearly clean; 64 samples (41.83%)fairly clean; 78 samples (50.98%) moderately clean; while 3 samples (1.96%) were found to be dirty. On the other hand, out of 153 sediment samples of clarified milk, 145 samples (94.77%) were found to be clean; and 8 samples (5.23%) nearly clean.

See Table I.

TABLE I.

Report showing grading of samples taken each day. Grade each days milk as follows:

1. Clean.
2. Nearly clean.
3. Fairly clean.
4. Moderately clean.
5. Dirty.
6. Filthy.

Sample of Original milk is taken in clean pint bottle from receiving vat after stirring well.

Sample of Clarified milk is taken in clean pint bottle from pasteurizer before pasteurization after milk has passed through the clarifier.

Sample of Pasteurized milk is taken in clean pint bottle from pasteurizer after pasteurization is completed.

(In each day pasteurized milk is clarified before pasteurization).

TABLE I. (Continued).

Date	Original Milk	Clarified Milk	Pasteurized Milk
Oct. 4, '14	Moderately clean	Clean	---
" 5	"	"	---
" 6	"	nearly clean	---
" 7	"	clean	---
" 8	"	"	---
" 9	"	"	---
" 10	"	"	---
" 11	"	"	---
" 12	clean	"	---
" 13	"	"	---
" 14	moderately clean	"	clean
"15	"	"	"
" 16	"	"	"
" 17	"	"	"
" 18	"	"	nearly clean
" 19	"	"	"
" 20	"	"	clean
" 21	"	"	"
" 22	"	"	"
" 23	"	"	"
" 24	nearly clean	"	"
" 25	moderately clean	"	nearly clean
" 26	"	"	clean
Nov. 1	fairly clean	"	"
" 2	moderately clean	"	"
" 3	"	"	"
" 4	"	"	"
" 5	"	"	"
" 6	"	"	"
" 7	"	"	"
" 8	"	"	"
" 9	farily clean	"	"
" 10	moderately clean	"	"
" 12	"	"	"
" 13	fairly clean	"	"
" 14	"	"	"
" 15	"	"	"
" 16	"	"	"
" 17	moderately clean	"	"
" 18	"	"	fairly clean
" 20	dirty	"	clean
" 21	moderately clean	"	"
" 22	nearly clean	"	nearly clean
" 23	moderately clean	"	clean
" 24	"	"	"
" 25	"	"	"
" 26	"	"	"
" 27	"	"	"

TABLE I. (Continued).

Date	Original Milk	Clarified Milk	Pasteurized Milk
Nov.29,'14	Moderately clean	clean	clean
" 30	"	"	"
Dec.1	"	"	"
" 2	"	"	"
" 3	"	"	"
" 4	fairly clean	"	"
" 6	moderately clean	"	"
" 7	"	"	nearly clean
" 8	"	"	clean
" 9	"	"	"
" 10	"	nearly clean	nearly clean
" 11	dirty	"	"
" 13	moderately clean	clean	clean
" 14	fairly clean	"	"
" 15	moderately clean	"	"
" 16	"	"	"
" 17	"	"	"
Jan.5	fairly clean	"	"
" 6	moderately clean	"	"
" 7	"	nearly clean	"
" 8	"	"	"
" 9	"	clean	nearly clean
" 11	"	"	clean
" 12	"	"	"
" 13	"	"	"
" 14	fairly clean	"	"
" 15	moderately clean	"	"
" 17	fairly clean	"	"
" 18	"	"	"
" 19	"	"	"
" 20	"	"	"
" 21	"	"	"
" 22	nearly clean	"	"
" 24	moderately clean	"	"
" 25	fairly clean	"	"
" 26	"	"	"
" 27	moderately clean	"	"
" 28	"	"	"
" 29	"	"	"
" 31	"	"	"
Feb.1	fairly clean	"	"
" 2	"	"	"
" 3	clean	clean	clean
" 4	fairly clean	"	"
" 5	"	"	"
" 6	"	"	"
" 9	"	nearly clean	"
" 10	"	clean	"
" 12	"	"	"
" 14	"	"	"

TABLE I. (Continued).

Date	Original Milk	Clarified Milk	Pasteurized Milk
Feb.16,'14	fairly clean	clean	clean
" 17	"	"	"
" 18	moderately clean	"	"
" 19	fairly clean	"	"
" 20	"	"	"
" 23	moderately clean	"	"
" 24	nearly clean	"	"
" 28	fairly clean	nearly clean	nearly clean
Mar. 1	"	clean	clean
" 2	"	"	"
" 3	"	"	"
" 4	nearly clean	"	"
" 5	fairly clean	"	"
" 7	nearly clean	"	"
" 8	fairly clean	"	"
" 9	"	"	"
" 10	"	"	"
" 11	"	"	nearly clean
" 12	moderately clean	"	"
" 14	nearly clean	"	clean
" 15	moderately clean	"	"
" 16	fairly clean	"	"
" 17	moderately clean	"	"
" 18	"	"	"
" 19	"	"	"
" 21	nearly clean	"	"
" 22	fairly clean	"	"
" 23	"	"	"
" 24	"	"	"
" 25	"	"	"
Apr.7	"	"	"
" 8	"	"	"
" 9	"	"	"
" 11	"	"	"
" 12	"	"	"
" 13	moderately clean	"	"
" 14	"	"	"
" 15	"	"	"
" 16	fairly clean	"	"
" 18	"	"	"
" 19	"	"	"
" 20	"	"	"
" 21	"	"	"
" 22	moderately clean	nearly clean	"
" 23	fairly clean	clean	"
" 25	"	"	"
" 26	"	"	"
" 27	"	"	"
" 28	"	"	"
" 29	"	"	"
" 30	moderately clean	"	"
May 2	"	"	"
" 3	fairly clean	"	"
" 4	"	"	"

Pasteurization.

The necessity for the pasteurization of milk is two-fold: First, to destroy the pathogenic bacteria which so often are the source of disease, and second, to check the too rapid multiplication of other bacteria, which allowed to go unchecked as is often the case when milk slightly contaiminated is left exposed to a temperature especially conducive to such multiplication, soon renders it unfit for use as a human food.

The large number of bacteria in the average market milk is especially harmful to infants because a large percentage of the bacteria present belongs to the putrefactive or closely allied kind. Those are largely responsible for the prevalence of diarrhea and general gastro-intestinal troubles and, therefore, for the high mortality rate among infants and children.

Whether raw or pasteurized milk is the more digestible is a question on which authorities, variously interpreting the few available facts, strongly differ. This naturally gives rise to no little discussion about the advnatages and disadvantages of pasteurization. Let it suffice to say that the advantages when pasteurization is properly done easily outweigh the corresponding disadvantages. Let it be borne in mind that properly pasteurized milk is decidedly different in character from merely boiled milk.

Pasteurization may be carried on in any one of three ways: First, by the "holding or intermittent method;" second, by the "flashing or continuous method;" and third, by the "bottle or final container method." In all three

of these methods the milk is first heated to a specific high temperature and is then rapidly and artificially cooled to a specific low temperature sufficient to check the speed of bacterial multiplication. By this general process at least 95% of the general mass of bacteria are destroyed, thus improving the keeping quality of the milk and rendering it a safe food.

The first mentioned method of pasteurization generally known as the "holding or intermittent method," also known as "perfect pasteurization" is as follows: The milk is first heated to comparatively a low temperature, somewhere between 140° and 155° F. At 140° F. the minimum exposure should be twenty minutes. For every degree of heat above 140° F., however, this minimum may be reduced one minute. In no case, however, should the minimum be less than five minutes. This method is considered the most effective from several points of view, and is therefore used most extensively.

The second, known as the "flashing or continuous method" proceeds by heating the milk to a temperature higher than that desired in the "intermittent method," somewhere between 160° and 175° F., and with less than a minute's exposure. The efficiency of this method depends naturally upon the length of time the milk remains in the pasteurizer. If the milk flows too rapidly, it will not be sufficiently heated, while if it flows too slowly, it is likely to become overheated. The results, therefore, will depend upon the time of

exposure, which in turn depends upon the speed of the milk flow.

In the third method, commonly known as the "bottle or final container method," the processi is somewhat similar to that of the "holding or intermittent method." It differs, however, in that the milk while being heated is kept either in a bottle or in a small container, as the case may be, instead of being contained in a large vat or pasteurizer. This method is preferable in at least one respect; viz., it does away with the chance of contamination that is possible during the coding, bottling and delivering of the milk pasteurized by either of the other methods. It is, however, the most expensive method of the three.

(Bearing in mind the facts that pasteurized milk is just as prone to become infected or re-infected, if exposed, as raw milk; also that once infected, the bacteria multiply more rapidly herein because the germicidal properties of this milk have been destroyed by the heat attendant upon pasteurization and the surviving bacteria consequently do not have so severe a struggle for existence, we must take care that that the pasteurized milk is kept cool and free from all possible contamination. Again, those bacteria that survive the process of pasteurization will multiply very rapidly if the milk is allowed to reach a warm temperature, and will thus usually change the taste to a rather bitter and irritating one. Sometimes, however, this multiplication of bacteria produces no noticeable change in either the taste or the appearance of

The milk under consideration).

The type of pasteurizer used in the following investigation was the "Perfection," which has a capacity of 200 gallons of milk. The quantity of milk to be pasteurized was first placed in the pasteurizer, where it was heated by means of a revolving coil of pipe extending horizontally across the pasteurizer, through which coil hot water was passed. When the milk thus heated reaches a temperature of 140° F. the heat is shut off. This temperature is kept approximately constant for twenty minutes, then it is rapidly cooled by the forcing of cold water through this same coil. When the milk has been cooled to 75° or 70° F. ice and salt are mixed with the cold water in the tank connecting with the coil. The brine resulting from this mixing is now forced through this revolving coil. The purpose of this is to cool the milk to a temperature of 50° F. or below, as quickly as possible. This temperature, it will be recalled, prevents the too rapid multiplication of bacteria.

See Table II. Record of Pasteurization of Milk.

c. 10, 1914 to May 4, 1915).

Date	Temp. milk b pasteu	Cream Past.	Distinctness of cream line	Lump of Butterfat.
Dec.14:	-	1/2"	hardly seen	none
Jan. 5:	-	3/4"	"	Some
" 18:	-	1/8	"	"
Feb. 2:	87	3/4"	"	"
" 9:	82	1/4	fairly dist.	slight
Mar.12:	80	3/4	Hardly seen	some
" 18:	71	7/8	"	"
" 19:	82	1/4	"	"
" 23:	84	1/4	"	"
Apr. 7:	87	3/4	"	"
" 9:	82	1/4	"	"
" 13:	72	1/2	"	slight
" 15:	90	1/2	"	large
" 23:	89	-	destroyed	"
" 25:	85	-	"	"
" 28:	83	-	"	"
" 30:	77	-	hardly seen	slight
May 2 :	82	-	destroyed	some
" 3 :	77	-	"	"
" 4 :	72	-	"	"

Sample the cream line was measured in neck
from receiv were not able to measure the absolute
from pasteu comparison was made between the raw
they were e lk.
four hours.

From the commerical standpoint the practical value of this method of pasteurization is determined in the light of the following considerations: What bactericidal afficiency has been secured; what effect has this pasteurization had on the cream line; and what is the intensity of the cooked flavor or taste produced. It will readily be seen that the higher the temperature, the longer the exposure, and the more rapid the cooling, the better will be the results from the standpoint of the destruction of bacterial life. On the other hand, too high a temperature and too long an exposrue so alter the physical and chemical condition of the milk that the cream does not rise naturally but comes more completely emulsified, i. e., the clusters of fat globules sometimes break up into smaller bodies, and occasionally these globules as a result, exist individually and independently. Again, an extremely high temperature or prolonged exposure develops what is known as a "Cooked flavor" in the milk.

Furthermore, the public usually judges milk by the amount of cream that rises. This is especially true in the case of the bottled milk where the location of the "cream line" is so easily detected. This test, the only one used by the consumer in deciding upon the richness of his milk, is, of course, not an accurate one for determining the richness of milk, but the appearance of the cream line, too often serves as the only basis for judging the quality of supply.

As this is his standard, care should be takne that pasteurization influence the creaming ability of milk as little as possible where said milk is to be used for commercial purposes. It might be interesting to note that in Europe conditions are otherwise. There the customer is accustomed to the receiving of heated or even boiled milk and consequently has come to understand that a poor cream line does not necessarily mean milk that is deficient in the normal amount of fat. The accompanying table gives statements from some authorities relative to the effects of heat on the creaming ability of milk.

See Table III.

Table III.

AUTHORS	STATEMENTS.
Roseman (a)	"Milk may be heated to 145° F. for an hour without markedly influencing the cream line. If milk is heated somewhat higher than this, say 148°F or for a longer time, the cream layer will blend with the milk below. The heating of milk for half an hour at a temperature of 150°F. or over, has the effect of entirely preventing the rising of cream or of delaying it very materially."
Michels (b).....	"155°F. for 1 minute affects cream line
	145°F. for 35 minutes affects cream-
Savage (c)	line."
	"At 71°C. (159.8°F.) the milk is affected and the cream will not rise properly."
Ward (d).....	"Exposure to 160°F. for one minute, or longer exposure to 140°F. are both safe."

(a) "The Milk Question"
(b) "Market Dairying and Milk Products," by Michels
(c) " Milk and Public Health" by Savage.
(d) "Pure Milk and the Public Health" by Ward.

The third point of consideration of the practicability of pasteurization, i. e., the question of the importance of a cooked flavor or taste in milk, is one that differs greatly with the locality concerned. In Europe, for example, where the majority of the consumers are accustomed to heated and boiled milk, there is little if any objection on this score Many of the consumers actually prefer the heated milk. From the standpoint of the milk venders of this country, however, it is desirable to avoid this cooked flavor as a result of the process of pasteurization as much as possible. The American consumer strenuously objects to any such flavor. The following table records statements authorities in regard to this matter of a cooked flavor or taste in milk as a result of pasteurization.

See Table IV.

TABLE IV.

AUTHORS	STATEMENTS.
Wing (a).....	"Milk may be heated to 165°F. if quickly cooled afterwards without developing a boiled taste."
Mackay and Larsen (b).....	"When milk is heated to 160°F., or above, it assumes a distinctly cooked taste, which makes it disagreeable as a food for many people
Mcihels (c).....	"150°F. for 40 minutes does not affect taste, 167°F. for several minutes taste affected."
Rosenon (d).....	"The cooked or scalded taste appears at about 70° C.(158°F.) and becomes more pronounced the higher the temperature."
Ward (c).....	"This (cooked flavor) is left permanently in milk exposed to about 170°F. for 15 minutes. Exposure to 170° F., in a closed vessel followed by immediate cooling is the highest temperature that may be used without leaving a cooked taste. Ten minutes at 160° is safe.

TABLE IV. (Continued).

AUTHORS	STATEMENTS.
Aikman (f).....	"65° C.(149°F.) for 20 minutes induces a cooked flavor but this disappears on cooling. 70°C. (158°F.) permanent change in taste.

(a) "Milk and Its Products," by Ving.

(b) "Principles and Practice of Buttermaking," by MacKay and Larsen.

(c) "Market Dairying and Milk Products," by Michels.

(d) "The Milk Question," by Rosenan.

(e) "Pure Milk and the Public Health," by Ward.

(f) "Milk its Nature and Composition," by Aiken.

As people differ widely in their ability to detect this cooked flavor in pasteurized milk, it becomes exceedingly difficult to determine definitely at just what point this flavor is first detected. Again, some authorities affirm that milk heated in closed vessels has a much less pronounced flavor than has milk heated in open vessels.

The following experiment, in which tests to determine the creaming ability, distinctness of cream line, and flavor of milk after pasteurization at varying temperatures and with varying periods of exposure, was made by the writer in this milk plant with the following interesting results:

Several samples of milk contained in half-pint bottles were heated, each to the temperature desired for it, by immersing in hot water kept to the desired temperature by a gas flame. After each sample had been exposed to its desired temperature for a given time, it was taken out of the bath and carefully placed in brine, where it was left until cooled to a temperature of 50° F. or lower. As a second test, some bottles were submitted to the rapid cooling as in the first case, while others were cooled slowly by allowing them to remain one and one-half hour thereabout in room temperature and after that by placing them in brine. Each sample of both tests, after being thoroughly cooled, was poured into a 100 c.c. graduated cylinder and tested for the above qualities after remaining in the refrigerator twenty-four hours. Table V. is designed to show the effect of high

temperature and length of exposure on the creaming ability and flavor of pasteurized milk; while Table VI. shows the average result of the degree of rapidity of cooling upon these same qualities of pasteurized milk.

See Tables V and VI.

No. of Sample	Te wh he
1	R
2	
3	
4.	
5	
6.	
7.	
8	
9	

The abov

for each.

cubic cent

was 3.6.

No. of Sample	Te W H
1	Re
2	
3	
4.	
5.	
6	
7	

ght

tected.

T

trials for

100 cubic

was 3.7.

before put

Results.

As shown in Table V, sample 2 had no effect upon the creaming ability or cooked flavor in milk.

Sample 3 had the slight effect of preventing the rising of cream but there was no difference in distinctness and in flavor or taste.

Samples 4 and 5 were affected in distinctness of cream line and showed a shallow cream layer, but no cooked flavor was developed.

In sample 6 the milk was affected greatly in amount of cream and slightly in distinctness of the cream line, but no cooked flavor or taste was recognized.

In sample 7 the cooked flavor was slightly developed in the milk but other conditions were about the same as those in sample 6.

In sample 8 and 9 the cream line was destroyed entirely; while cooked flavor was developed slightly in sample 8 and markedly in 9.

As shown in Table VI, sample 2, the milk was not affected as regards creaming quality nor in flavor or taste.

Sample 3 showed an apparent decrease in the amount of cream, but no effect on distinctness nor in flavor or taste was noticeable.

In sample 4 the milk was affected markedly as regards creaming ability, slightly as regards distinctness, but not at all as regards flavor or taste.

In sample 5 the milk was affected slightly more than in sample 4 in all these respects.

In sample 6 the milk was affected largely in creaming quality and in distinctness, and slightly in flavor.

In sample 7 the milk was so affected in every respect as to be easily detected as heated milk.

Conclusions.

The investigation here reported is probably not sufficiently authoritative to warrant the drawing of absolutely definite conclusions. It is evident, however, that the creaming quality and cooked flavor of pasteurized milk are influenced by various factors. The principal of these factors are:

(1) The temperature to which the milk is heated

(2) The time during which milk is exposed to the high temperature

(3) The amount of agitation to which the milk is subjected, especially when at high temperature.

(4) The rapidity of cooling after heating

(5) The clarification of the milk before pasteurization.

Reasoning from the result of the investigation of the practical clarification and pasteurization of milk as regards it creaming quality and flavor, as well as from the particular experiment here conducted, we are led to the

following conclusions regarding the effect which this clarification and pasteurization has upon the visible or tangible quality of milk: First, a comparison of the result of the sediment test on clarified and original raw milk respectively shows that this clarification by means of centrifugal force is instrumental in removing the greater part of the dirt and sediment to be found in original raw milk; second, it is possible to pasteurize milk by heating it to a temperature of 140°F. and exposing it to this temperature for twenty minutes, then rapidly cooling it to a temperature of 50° F. or below, without any undesirable effect on the quality of the milk under considerationbeing noticeable. Now, according to themajority of bacteriologists the heating and cooling of milk within these temperatures are quite sufficient for bactericidal efficiency. If, however, milk is heated during the pasteurization process at a temperature higher than 140° F., or if it is exposed while at this temperature for a longer period than twenty minutes, it will be affected in creaming ability, or in flavor, or, as sometimes happens, in both. It is well to note, however, that the excess of temperature above 140° F. affects this creaming quality far more than does the excess exposure. Again the rapidity in cooling is necessary both for hygienic reasons and for the prevention of cooked flavor or taste. This rapidity of cooling, however, does not materially affect the creaming ability of the milk.

Agitation of the milk, especially when this milk is at a high temperature, has a distinctly noticeable effect upon the cream line. The greater the amount of this agitation the less the visible amount of cream. This can be explained by the presence of lumps of butterfat seen floating on the surface of the milk that has been so agitated after it is cooled. An investigator experimenting along this line discovered that as the speed of the agitator which kept the milk in motion was reduced these lumps of butterfat showed a tendency to disappear until when this speed reached a certain minimum they disappeared entirely.

It has also been discovered that the agitation caused by centrifugal force in the clarification of milk heated to an extremely high temperature also affected the creaming quality. It did this first by separating the globules of butterfat from the milk, then causing these globules to run together, thus forming lumps of butterfat that float on the surface of the milk.

Again, it has been observed that milk heated in closed vessels does not form any pellicle even when heated to the boiling point; while milk exposed to the open air during the process of heating always shows a pellicle on its surface,- a pellicle that reappears if removed by skimming. This pellicle, it would, therefore, seem, is mainly due to the evaporation of the surface layer of the milk.