SOME PUBLIC HEALTH ASPECTS OF MARKET MILK PROCESSING METHODS

by

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INTRODUCTION

From the viewpoint of public health, pasteurization of milk is one of the greatest weapons of preventive medicine, since it is only by pasteurization that a safe milk supply can be guaranteed to the consuming public.

From earliest times, mankind has applied heat to food in order to make it palatable, digestible and safe, but it is only in the past two centuries that he has heated it with the additional object of preserving it.

The earlier work was mainly concerned with the canning industry. The bacteriological principles which were revealed by Pasteur's research led to a sounder basis for the application of heat in food preservation.

Pasteurization has expanded considerably beyond its original purpose of infant feeding. Such expansion is, in part, due to such vigorous exponents as Koplick, Soxhlet, Jacobi and Straus.

By 1895 the problems of raw milk contractors were becoming increasingly greater. These dealers were faced with competition from pasteurized milk depots which had been started in New York, Brooklyn, Pittsburgh and Cincinnati. In addition, their sources of supply were being pushed farther and farther away, with consequent deterioration in keeping quality.

Under these conditions, pasteurization, with its freedom from disease germs and the increased keeping quality of the finished product, appealed forcefully to the city milk dealers.

Pasteurization began coming into general use in the United States around the year 1900, the prime object of pasteurization at that time being to increase the keeping quality of the milk.

The dealers generally adopted the flash process of pasteurization, using approximate exposures of 160° - 170° F. for 15 - 30 seconds. This system was misused, depending as it did upon manual operation with no automatic safeguards to ensure proper time and temperature exposure.

This system, with its primary emphasis on the prolongation of keeping quality, was not adequate from the public health standpoint.

From the beginning the need of a system which would give a reasonable assurance of safety as well as better keeping quality was recognized.

This demand resulted in the holder method of pasteurization whereby milk was heated at lower temperatures (143° F.) for longer periods of time (30 minutes). This system through the past forty years has proven to be practical and effective.

It was through a desire for a continuous system which could operate on regenerative principles that a method similar to the earlier flash pasteurization came into vogue. This high-temperature short-time

Since present day methods of laboratory control make use of tests which measure whether milk has been pasteurized in a safe manner, much public health thinking has been turned towards the latent danger of after infection or bacterial contamination of the milk subsequent to pasteurization.

Concern regarding recontamination has been intensified due to the introduction of new processes and equipment. In this regard, perhaps the homogenizer, difficult as it is to sanitize, has added more to the complexity of the problem than has any other single piece of equipment connected with the processing and pasteurization of milk.

While originally the production and distribution of pasteurized and homogenized milk was limited almost entirely to the large urban centres, the consistently increasing demand for this product has brought about the introduction of homogenization of milk in many of the smaller milk plants.

It is from homogenization after pasteurization that the greatest danger of contamination of pasteurized milk arises. Public health regulations have attempted to place limitations on the equipment with which the milk comes in contact after pasteurization. Unfortunately the presence of the lipase enzyme in milk complicates the homogenization process. This enzyme must be inactivated by heat either immediately before or after homogenization to avoid development of rancid flavors. Not all milk plants which are homogenizing milk have the necessary preheating equipment which would enable them to homogenize before pasteurization.

Since many of these plants are working on what is considered a scant profit margin, it has been the desire of public health officials not to work an economic hardship on plant management by insisting on installation of equipment which would enable milk to be homogenized before pasteurization.

In spite of all devices, automatic and otherwise, for pasteurization equipment, the possibility of personal negligence will always be real. In an attempt to measure the public health dangers arising from possible negligence which could lead to contamination of milk subsequent to pastaurization, a study was made of the common processing sequences in commercial use.

This study was made in an attempt to determine the methods of processing and handling of milk and milk products which would be acceptable from a public health standpoint. The main objective was as follows:

1. To determine the effect of the processing sequence on the bacteriological quality of milk.

And incidental to it:

2. To suggest practical treatments for the homogenizer to minimize contamination from this source.
3. To determine the applicability of dye reduction quality tests on a predominately heat resistant bacterial flora.
4. To develop a more objective keeping quality test for pasteurized milk.
5. To study the increases in bacterial counts in homogenized milk

in an attempt to determine what portion is due to breaking up of bacterial clumps.

Trout (36) stated that several systems or sequences of processing involving homogenization of milk were possible, any of which, with proper control, would yield a satisfactory product. Among the possibilities that he reported were:

a) Clarify, preheat, homogenize, pasteurize, cool.

b) Clarify, preheat, pasteurize, homogenize, cool.

c) Preheat, clarify, homogenize, pasteurize, cool.

d) Preheat, homogenize, clarify, pasteurize, cool.

e) Preheat, clarify, pasteurize, homogenize, cool.

Hood and White (19) added to this list with the following processing methods:

a) Pasteurize, clarify,* homogenize, cool.

b) Clarify, pasteurize, homogenize, cool.

c) Homogenize, preheat, clarify, pasteurize, cool.

d) Pasteurize, homogenize, clarify, cool.

Investigators have long realized that, when milk is homogenized after pasteurization, the likelihood of post-pasteurization contamination is increased. Trout (35) mentioned this possibility but also pointed out other factors which influence the choice of the point at which to homogenize. These considerations included volume and percentage of milk to be homogenized, the facilities for preheating to the temperature suitable for homogenization and for rapid inactivation of the lipase enzyme after homogenization.

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* Clarification and filtration are interchangeable.

According to Dearstyne and Ewing (8) the sanitary significance of the cleanliness of the equipment with which pasteurized milk comes in contact should never be underestimated. Since local health ordinances, e.g. (23) often prohibit the filtration, straining or clarification of milk after pasteurization, it has been assumed (8,39) that the equipment most likely to be in contact with pasteurized milk is the homogenizer, pipe lines, surface or plate coolers, bottling machine or the bottles and caps themselves. That this equipment may have been responsible for post-pasteurization contamination of milk is a matter of record whether it arises from the pipes (7,25,27), surface or plate cooler (15,38), bottling machine (12), bottles and caps (8,20,26) or the homogenizer (10,22,36).

During the 1930's the earlier types of homogenizers were replaced by new, completely demountable, sanitizable machines. Tracy (33) and others (34,40) believed that, with these new machines and if proper procedures were used for washing, sanitizing and processing, the objections to the homogenizer as a source of bacterial contamination of the milk might largely be overcome.

While the use of the homogenizer after pasteurization almost invariably resulted in an increase in the bacterial plate count of the milk being processed (36), this may not always have been due solely to bacterial contamination from the homogenizer itself. Various processes have long been known to break up the clumps of bacteria. Hammer and Hauser (17) noted that clarification breaks up the bacterial clumps as does the ice cream freezer as reported by Hammer and Goss (16) and

Ellenberger (11). Bishop and Murphy (4) were among the first to note that the homogenizer also breaks up the clumps of bacteria resulting in a higher plate count. Tracy (33) stated that this increase was also related to the types of bacteria present in the milk. When large numbers of clumping organisms were present, homogenization would break up the clumps producing an apparent increase in the numbers of bacteria present. James (21) concluded that, even though the machine was sterile, there was in increase in plate count due to breaking up of clumps by pressure and agitation during homogenization. He further stated that this increase varied because of the different numbers and types of bacteria resisting pasteurization.

It should, however, be emphasized that the foregoing authorities did not overlook the possibility of the homogenizer being a source of serious bacterial contamination, especially when cleansing and sanitizing practices tended to be neglected. The conclusion to be drawn might well have been in agreement with that of Tracy (32) who stated that, when the modern type of sanitary homogenizer was used, it was possible to homogenize milk without any appreciable bacterial contamination, provided good sanitation methods were used.

SECTION I

EFFECT OF THE PROCESSING SEQUENCE ON THE BACTERIOLOGICAL QUALITY OF MILK

PROCEDURE

The processing equipment that was used for the experiments on the effect of variations in the sequence of milk processing was that normally used in the operations of the commercial dairy at the University of Manitoba. This equipment consisted of a stainless steel dump tank, a tubular pre-heater, piston type homogenizer, spray type vat pasteurizer, enclosed surface cooler and a power bottle filler and capper. The pipes and fittings used throughout this system were of stainless steel construction.

The milk supply used in the experimental work was that normally obtained from the University dairy herd supplemented from time to time during the length of the project by additional supplies from an independent milk shipper.

When a sequence trial was decided upon, the equipment was placed in position to carry out the particular variant under study and the processing sequence was begun.

Prior to the passage of any milk through the system, chlorine sterilizer of a hypochlorite type (150-200 p.p.m.) was pumped through the system for a five minute period, being brushed over any non-exposed surfaces. The processing equipment had in every case been rinsed and dismantled after the previous day's processing, washed in warm (110 - 120^{o} F.) water containing a balanced general purpose cleanser, rinsed

with hot (170 - 185° F.) water and allowed to dry. The equipment was reassembled and sterilized just prior to use in each test.

Samples were taken at various points in the processing sequence e.g., before and after filtering, preheating, homogenizing, pasteurizing and cooling and bottling. All samples to be correlated were taken as closely together as was possible within the sequence so as to represent a common milk supply. All samples were collected in a manner described by Standard Methods (30) or in the case of the line sampling technique as suggested by Berger and Anderson (3) with the exception that samples were taken from pipe lines by loosening previously disinfected fittings and allowing free flow from connection for 30 seconds before sample was obtained. Sample size was in all cases at least 4 ounces, the 8 ounce size being used where sample was to be later sub-divided.

Samples were immediately placed in an ice-water bath and held under refrigeration until plated. In no instance was this period of refrigeration greater than 2 hours. Samples were plated for total bacteria count on T.G.E.M. agar according to Standard Methods (30). They were plated in duplicate in at least 2 dilutions and were reported as suggested by Standard Methods (30), incubation being at 95° F. for 48 hours. Samples that were analyzed by methylene blue and resazurin tests were carried out according to method outlined in Standard Methods (30). Readings were taken every 15 minutes until reduction proceeded beyond Munsell color standard (P.7/4) in the case of resazurin and at least 4/5 decolorization of visual portion

of contents with the methylene blue test. Hourly inversion of tubes with both tests was carried out.

Laboratory pasteurization was carried out on the raw milk samples as well as those taken from the pasteurizing vat at the end of the pasteurizing period. Laboratory pasteurization was carried out according to methods prescribed by Wilson (39).

To assess keeping quality and influence of post-pasteurization contamination it was decided to re-test the samples after incubation for 24 and 48 hour periods. Consequently the samples from the pasteurizing vat immediately after pasteurization, from the first milk into the bottle filler bowl and from the milk into the filler bowl after ten minutes continuous flow; (Sample points 2,3 and 5 respectively), were subdivided into sterile bottles and incubated at 55° F. They were withdrawn from incubation at 24 and 48 hour periods and analyzed for total bacteria count, resazurin and methylene blue reduction according to Standard Methods (30). This method of assessing keeping quality is closely related to methods proposed by Berger and Anderson (3).

For each sequence bacterial counts are arithmetically shown for each separate trial, they are logarithmically averaged for the sequence and antilogarithms are presented for these logarithmic averages. In all instances bacterial counts as reported represent standard plate counts per cubic centimeter. Unless otherwise stated resazurin and methylene blue reduction times are reported in minutes.

RESULTS

To illustrate the bacteriological "effect" of sequence changes 72 separate pasteurizations were carried out using 6 different processing sequences, twelve pasteurization trials being completed with each sequence.

As may be seen from Table 1 there were three sequences which homogenized before pasteurization and three sequences which homogenized after pasteurization. All the six sequences varied mainly in the position that the various steps within the sequence hold in relation to each other.

Table 1. Variations in processing sequences

Type of seq.	Seq.	Processing steps within sequence
Homo. before past.	A	Filter, preheat, homogenize, pasteurize, cool.
	C	Preheat, homogenize, filter, pasteurize, cool.
	F	Preheat, filter, homogenize, pasteurize, cool.
Homo. after past.	B	Preheat, filter, pasteurize, homogenize, cool.
	D	Pasteurize, filter, homogenize, cool.
	E	Pasteurize, homogenize, filter, cool.

To more closely study the effect of sequence change observation of the results within single sequences is necessary. To illustrate this, Table 2 (a to f) shows the bacterial counts for five separate sampling points within the sequences.