SOME PRACTICAL ASPECTS OF PROCESSING FLUID MILK

RASHMI KANT NAGAR

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DEPARTMENT OF DAIRY SCIENCE
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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY SHRI RASHMI KANT NAGAR ENTITLED "SOME PRACTICAL ASPECTS OF PROCESSING FLUID MILK" BE ACCEPTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURE (DAIRY SCIENCE).

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ABSTRACT

To assess the feasibility of marketing raw chilled milk, 146 samples were collected from organized dairy farm, rural collection centres of processing plant and city market, and their shelf life determined after different treatments. The shelf life for the ambient temperature exposed (0, 1, 2 and 3 hr) and slowly chilled raw milk was 24.0, 19.1, 17.1 and 12.1 hr at 45°F, and 18.1, 15.2, 13.7 and 12.9 hr at 70°F. For instantaneously chilled milk it was 26.0, 21.6, 18.9 and 15.2 hr at 45°F and 16.5, 14.7 and 13.7 hr at 70°F. The shelf life of the pasteurized bottled milk at 45°F, 70°F and room temperature was found to be 68, 19 and 9 hr respectively. The quality of milk was evaluated by performing one-hr resazurin test, standard plate, coliform and psychrophilic counts and acidity and non-protein nitrogen determinations on all samples. According to one-hr resasurin test, 82.7 per cent samples of dairy farm, 11.2 per cent of rural collection centres and 34.3 per cent samples of city market milk were found satisfactory. There was high incidence of contamination with coliform and psychrophilic bacteria in rural centre and city market milk. The bacterial counts of pasteurized milk were also very high and its quality poor as revealed by short shelf life.

The results of the present study suggest that the quality of both raw and pasteurized milk was very poor because of the unhyginic conditions of milk production in villages and the high temperature holding for long time in collection and transport. The short shelf life of the high count pasteurized milk when exposed to atmospheric temperatures for hours in distribution, would make it very difficult to rechill or repasteurize the returned milk for redistribution as fluid milk. The feasibility of marketing good quality raw chilled milk deserves consideration under present conditions.

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(R.K. NAGAR)

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INTRODUCTION

Milk is of great value as protective food. Besides essential fatty and amino acids, it supplies all vitamins and minerals. Its value is further increased in Indian diet as milk is the only source of animal proteins for vegetarian people. But, unfortunately, milk is not easily available to majority of people because of short supply and high sale price. The per capita consumption of milk and milk products in India is only 5.1 ounces per day as against a minimum of 10.0 ounces recommended by the National Nutrition Advisory Committee. Because of non-availibility of animal proteins, malnutrition hazzards develop in case of children, adults and expectant mothers. The solution of the problem lies in increasing milk production and proper utilisation of milk produced.

Only about 40 per cent of total milk produced in the country is consumed in fluid state. The remaining 60 per cent is converted into milk products. About 7 per cent of total milk produced is lost due to bacterial spoilage every year. The spoilage occurs due to contamination at each stage of production, handling, processing and distribution. Major part of market milk distributed by unorganised sector is invariably adultrated.

Another factor that contributes greatly to spoilage is the hot climate of the country. If somehow the spoilage is checked or minimized, the total quantity of milk available for consumption would increase and more milk would be supplied for fluid consumption.

The quality of market milk available for processing to the dairies varies widely. Milk produced in organised sector under better husbandry practices is comparatively better in quality, whereas the milk produced in villages under unhyginic conditions is of poor quality. As such, the quality of pasteurized milk in the latter case is also bound to be poor. Moreover, pasteurized milk has to be boiled periodically to increase its shelf life, because of non-availibility of refrigirators in most households. With the increase in atmospheric temperature, the bacterial activity increases. The milk provides an excellent medium for bacterial growth and spoils quickly if not cooled properly. A quick change in temperature has retarding effect on the growth and activity of bacteria. As such, if the milk is collected immediately after production and chilled, its keeping quality can be considerably prolonged. If the chilled raw milk has shelf life sufficiently longer so as to reach consumers in good condition, it can be sold as raw instead of pasteurized milk which also normally needs boiling when not stored in a refrigirator. Further, the sale price of raw milk would be lower by cutting down the cost of processing.

The present investigation was undertaken to study the initial and storage quality of raw pasteurized milk. By the use of simple bacteriological and chemical tests, the initial quality of milk was determined. Thereafter the milk was chilled and stored at different temperatures and its shelf life determined. A large number of samples of raw and pasteurized milk were analysed. The results of the investigation have been presented and discussed alongwith the findings of other workers in the following chapters.

REVIEW OF LITERATURE

In view of shortage of milk, the problem of safeguarding it against spoilage has assumed greater importance. The unhyginic conditions of milk production and handling coupled with hot climate of the country are two important factors that contribute to the initial poor quality and subsequent spoilage of milk in India. Considerable research work has been done on the quality of raw and pasteurized milk in the foreign countries. Standard Plate, Coliform and Psychrophilic counts and dye reduction, clot-on-boiling and acidity tests are among the methods commonly employed to judge the quality of milk.

The first systematic examination of milk supply was done in Boston by Sedgewick and Batchelder (1892). The public health requirement made the bacteriological examination a regular practice and in 1905, American Public Health Association appointed a Committee to standardize the procedure for milk testing. According to a report of the New Jersey Agricultural Experiment Station (1937-38), the keeping quality of high grade raw milk at low temperatures was found to increase when bottles were sealed under reduced pressure because of reduced rate of multiplication

of bacteria. At higher temperatures, however, the keeping quality was decreased owing to growth of proteolytic bacteria. Off-flavours except tallowyness were found to develop more slowly than under normal conditions.

Sherman et al. (1938) found the keeping quality of pasturized milk at 0°C better than that of raw milk. They reported destruction of bacteria growing at lower temperature and reduction in total bacterial numbers in pasteurized milk. Pasuca (1938) studied the keeping quality of raw and holder pasteurized milk at room temperature and at 40°F. He determined the fat, acidity, bacterial count and flavour, every 3 hours for room temperature and daily for cold store samples. Raw milk samples stored at room temperature were pasteurized after 6, 9 and 12 hours storage and those stored at 40°F were pasteurized after 24, 48, 72 and 96 hours. Pasteurized milk samples were repasteurized after 12,24, 36 and 48 hours. The author reported that the raw milk kept wholesome at room temperature for 12-15 hours and at 40°F for 3-4 days. Pasteurization after 24-48 hours storage prolonged the keeping quality by 6-7 days. Pasteurized milk at room temperature was found to remain wholesome for 20-24 hours. Repasteurization every 12 hours or before the milk developed an acidity of 0.15 per cent increased the keeping quality by 48-54 hours. At 40°F pasteurized milk remained wholesome for 6-7 days.

Valenzuda (1940) observed delayed bacterial development as measured by reduction of methylene blue in milk in which strips of copper and brass were immensed for several hours immediately after milking. Sherman et al. (1941) found that good quality raw milk usually kept for about 4 weeks at 0°C whereas comparable pasteurized milk kept for 8-12 weeks. Inoculation of pasteurized milk with minute amounts of raw milk decreased its.keeping quality. Anderson (1941) discussed the influence of cooling milk on the growth of organisms. Nicholas and Anderson (1942) studied keeping quality of pasteurized and raw milks at 40°F. They observed that when left undisturbed, pasteurized milk did not show signs of definite spoilage until 21-28 days. Similar milk removed daily, shaken for 10 minutes and permitted to stand at room temperature for an hour before being returned to the refrigirator, kept wholesome for 12-30 days. Raw milk samples with initial plate count of 31000-39000 per ml spoiled in 4-7 days. The quality of pasteurized and homoginized pasteurized milk after storage for 28 days was considered equal to that of fresh milk as judged by standard plate count, tritrable acidity, fat and solid content, taste, odour and appearence.

Provan and Rowlands (1941) reported a keeping quality period of 2½-4 days for pasteurized milk in Midland areas of England. De-Soriano (1946) found keeping quality of commercially

pasteurized milk at 25°C to be between 12-30 hours. Despite their considerably large number in raw and commercially pasteurized milk, Thomas and Chandrasakher (1946) found no psychrophiles in laboratory pasteurized milk. They found samples of A-catagory by resazurin test with a keeping quality of greater than 8 days. Kennedy and Weiser (1950) found more psychrophilic bacteria in raw than in pasteurized milk and that storage at 10°C tended to increase their number. Erdman and Thornton (1951) found high psychrophilic count at 10°C and 4.5°C in larger percentage of samples of raw winter milk than summer milk. They concluded that high psychrophilic count in pasteurized milk indicated poor plant sanitation. Doetsch and Scott (1951) reviewed the problem of psychrophilic bacteria in milk.

Natvig (1947) observed that the coliform organisms tended to be more frequent in the raw milk from dairies than in those direct from farms. Buchbinder and Alffedythe (1947) found heat resistant coliforms of no perticular significance in pasteurized milk.

Cronshaw (1947) found post-pasteurization contamination responsible for reduction in keeping quality of commercially pasteurized milk to a great extent. According to Egdell et al. (1949), Swartling (1953) and Thome et al. (1957) reduction in shelf life of milk by 1½ - 6 days could occur as a result of

post-pasteurization contamination. Meyknecht et al. (1956) could not improve the keeping quality of milk by HTST pasteurization even when the temperature was raised to above 80°C. Swartling (1953) showed that the plate count of milk before and after laboratory pasteurization bore no relation to keeping quality (as judged by taste and smell) at 13°C and 18°C. The nature of the viable surviving bacteria was a highly important factor. Murrey (1953, 1954) reported that spore forming bacteria proliferated rapidly in pasteurized milk stored at 18°C. Off-flavours in the milk were generally related to the activity of spore formers.

The effect of storage at varying temperatures on the keeping quality and growth of microorganisms has been studied by various workers. Trout et al. (1953) stored pasteurized homoginised milk for 6 weeks without spoilage or with slight defect in flavour and taste of such milk. According to Dahlberg (1945) there was no increase in the total and coliform counts of milk upto 4 days when stored at 35-40°F. As the temperature was raised increase in the total and coliform counts was noted earlier. Similarly, Witter et al. (1959) observed that the rate of growth of psychrophites at 50°F was roughly twice than that at 40°F.

Anderson and Meanwell (1950) found that addition of 1 per cent poor quality raw milk during bulking before pasteu-

rization reduced the keeping quality of commercially pasteurized milk. Similar results were also obtained by Ashton (1962). Reports from many workers (Dahlberg, 1946; Bergwald and Josephson, 1947, and Calesloot, 1953) have suggested that the keeping quality is generally higher in winter months than in summer and that may be attributed to the higher rate of post-pasteurization contamination as well as increased rate of growth of microorganisms.

Phillips (1946) studied the influence of conditions of cold storage prior to distribution on the keeping quality of pasteurized milk. The milk after processing was kept in cold store. The ambient temperatures of cold store ranged from 50-60°F at 4:00 p.m. and 39° - 43°F at 7:00 a.m. the following morning. Duplicate bottles were also stored in a laboratory refrigirator at 39-43°F. Both sets of samples were then tested for keeping quality (C.C.B. end point) at atmospheric temperature and at 18°C and also by the methylene blue reduction test at 37°C after preliminary storage for 24 hours at atmospheric temperature and at 18°C. None of the refrigirated samples failed ½ hour methylene blue test after storage for 24 hours at atmospheric temperature but only 34 per cent of the duplicate samples from the dairy cold stores satisfied this standard. When stored at 18°C, 35 per cent samples from dairy cold stores became sour at the end of 24

hours but more of the refrigirated samples turned sour upto this time. Anderson et al. (1947) observed that the keeping quality of pasteurized milk tended to fall when the temperature at which raw milk was collected rose above 15.5°C and fell more markedly for collection temperatures of over 21°C.

Pahrsson (1949) found no difference in the quality of milk collected from 0-45 km, over 45 km and 60-70 km distance. The best quality milk was collected from suppliers supplying 0-25 kg or over 200 kg and worst from producers delivering between 50-100 kg. Weese and Henderson (1949) found pasteurized milk of good quality to keep well for 3-4 days after delivery under reasonably good condition of home refrigirator. Borger and Meyer (1954) reported that the quality of pasteurized milk depended mainly on the quality of raw milk. Similar results have been reported by Arima et al. (1965) and Franklin (1966).

Plommet (1956) studied the effect of domestic boiling, as was the prevelent custom in France, on microflora and constituents of milk. Since refrigirated storage of raw and pasteurized milk did not cause significant changes in the free amino acid content, Storgards and Linquist (1962) thought that this was not a satisfactory measure of "degree of freshness" of milk. Maxy (1966) reported that in freshly packaged milk, less than 10 gram negative organisms caused spoilage in 14-21 days, at 5°C and in 8-12 hours only at 32°C.

Willart and Sjostrom (1962) observed at pH 4.1 to 5.7 only a weak tipolytic activity in milk pasteurized for 20 seconds at 60-70°C and no activity in milk pasteurized at 73°C. Light has also been known to affect the keeping quality of pasteurized milk. Stadhouders et al. (1962) found milk contained in bottles which had no access to light, i.e., brown bottles had inferior keeping quality than the milk contained in the clearer bottles. It was indicated that the milk was a poorer medium of lactic streptococci in the presence of light than in the dark.

Hyozo and Nakanishi (1965) studied the shelf life of commercially pasteurized milk at 56°, 25°C and in refrigirator. All the milk samples heat treated at 75°C/15 minutes curdled within 24 hours at 56°C whereas no visible change was observed in 24 hours in the majority of samples heat treated at 130°C/2 second. All milks stored at 25°C showed visible changes, curdling or ~~xx~~ curdling and swelling within 24 hours regardless of the prior heat treatment given. Milk samples stored in refrigirator for 15 days showed no visible change.

In India very little work has been done on the quality of market milk. Joshi (1916) studied the quality of market milk in Bombay city. The average bacterial count/ml of milk varied from 8,981,000 to 19,767,000. Verma et al. (1944)

studied the bacteriological quality of market milk obtained from different sources in Bangalore.

A comparative study of cooling alone at 40°, 50° and 60°F to a process of heating and than cooling to 40°F in order to prolong the shelf life of milk was made by Gunmery et al. (1950). They found that heating and then cooling to 40°F doubled the marketable life of milk exposed to atmospheric temperatures at 74-98.6°F. Storage in insulated containers increased the effectiveness of simple cooling more than heating and cooling. Ageing milk before treatment affected the efficiency of cooling more than that of pasteurization. Milk aged for 6 hours was more effectively pasteurized by heating at 170°F/10 min than at 145°F/30 min. But there was no difference between the two processes for fresh milk or milk aged for 3 hours.

Few studies have been reported on processing for improving keeping quality of milk. According to a report on an ICAR scheme (1959), keeping quality of milk at Anad was 15-20 hours at 30°C while at Bombay it ranged from 21-24 hr at 28°C and from 16-19 hours at 37°C. It has been shown in the same report that there was no improvement in the keeping quality of HTST pasteurized milk heated beyond 74°C/16 sec, although higher temperatures tended to reduce the number of surviving microflora. Similar observations have also been

made by Varma et al. (1959). Natrajan and Laxminarayana (1962) found the keeping quality of milk almost the same regardless of raising the pasteurization temperature to more than 77°C.

The rate of spoilage of pasteurised milk stored at different temperatures was determined by Thakre and Nambudripad (1962). According to these authors keeping quality of pasteurized milk could be expressed by the following formula:

$$Y \text{ hr} = X \text{ hr} \ \frac{(t_{2-3})^2}{(t_{1-3})}$$

Where Y is the keeping quality in hours at a temperature t_1 and X is the keeping quality in hours of pasteurized milk stored at a temperature t_2. This formula has been found to be valid between the temperature ranging between 5°C and 33°C.

MATERIALS AND METHODS

Collection, handling and treatment of samples:

For the present investigation, 146 samples of raw and 70 samples of pasteurized milk were examined. Of the raw milk samples 69 were obtained from the milk produced at Rajasthan College of Agriculture Dairy Farm. These samples were from herd bulk milk produced under average sanitary conditions. Of the remaining samples, 41 were obtained from city market and 36 from the village collection centres of the Pilot Milk Supply Scheme, Udaipur, where the conditions of production and handling of the milk were generally unhyginic.

Raw milk samples:

All raw milk samples from different sources were collected asceptically in clean sterile glass bottles and cooled promptly to 2°C in an ice-box to minimize further multiplication of bacteria. The samples immediately on arrival at the laboratory were plated for the Standard Plate, coliform and psychrophilic counts. Simultaneoulsy determi-

nation of non-protein nitrogen, dye-reduction test and acidity test were also performed.

Pasteurized milk samples:

Of the pasteurized milk samples obtained from the Pilot Milk Supply Scheme, Udaipur, standard plate, coliform and psychrophile counts, acidity and non-protein nitrogen were determined.

Bacteriological examination of samples :

Standard plate count: Standard methods agar medium was used for determining total count. The medium was prepared from Difco dehydrated ingradients as specified in the standard methods for the examination of Dairy Products (1960). The plates were incubated at 32°C for 48± 2 hours.

Psychrophilic bacterial count: The procedure and medium as used for the standard plate count were also used for the determination of the psychrophilic bacterial count except that the plates were incubated at 5°C/7 days.

Coliform count: Violet Red Bile Agar was used for the determination of coliform count. Freshly prepared medium from Difco dehydrated ingradients with final pH of 7.4±0.1

was used. The plates were incubated at 35°C/20 hours. The procedure as specified in the standard methods was followed.

Preparation and plating of samples:

The plates were serially arranged and numbered according to the sample examined. Appropriate dilutions for the samples were selected and the samples diluted with the objective of securing 30 to 300 colories per plate. Usually dilutions of 10^4, 10^5 and 10^6 were found sufficient for the standard plate and psychrophilic counts, and of 10^2, 10^3 and 10^4 for the coliform count.

Duplicate plates were prepared using 12-14 ml medium for SPC and psychrophilic count and 14-16 ml for the coliform count, using Quebec Colony Counter, the plates were counted immediately on expiry of the incubation period. The averages of the duplicate counts were multiplied with the times of dilutions used and the results reported as counts/ml.

Sterilization of glassware and media:

All petri dishes, pipettes, sample bottles and glassware used in this study were sterilized in a Hot Air

Sterilizer at 180°C/4 hour. Similarly all water blanks and media were sterilized in an autoclave at 121°C/15 minitues.

In order to check sterility of glassware and dilution blanks respectively, the controlled plates with and without dilution water were also incubated after pouring the media. To check the sterility of the media used, 10 ml portion were taken in sterile test tubes and incubated at the required temperature for the required periods of time.

One-hour resazurin test:

The dye solution was prepared as per procedure of Chalmers (1955). One resazurin tablet (B.D.H.) was asceptically transferred to the sterile amber glass bottle and dissolved in 50 ml of cold sterile glass distilled water, closed with a screw cap and stored in a refrigirator.

After thorough shaking of samples 10 ml portion of milk was asceptically transferred to each standard, lebelled, identified and stoppered test tube and placed in an ice-box (2°C); 1.0 ml of resazurin dye was added with all asceptic measures. The milk and dye were mixed by gentle

shaking. The tube was then placed in a thermostatically controlled water bath maintained at 37°C ± 0.5°C. After one-hour of incubation, the samples were removed from the water bath, compared with a colour standard and graded for quality according to colour shades developed after the incubation period as recommended by Laxminarayana (1946).

Colour shade	Grade
Blue, lilac and mauve	A - (very good)
Pink, mauve and mauve pink	B - (good)
Pink	C - (fair)
Colourless	D - (poor)

Chemical examination of samples:

Acidity test: 10 ml portion of milk was drawn in a porcelene dish after thorough shaking and diluted with equal volume of CO_2 free distilled water. The contents were then titrated against N/10 NaOH using 1 per cent phenolphthlein as indicator to a persistant pink colour end point. The acidity was reported as per cent lactic acid.

C.O.B. test: The clot-on-boiling test was conducted as per procedure of Chalmers (1955). 2 ml of well shaken milk sample was drawn in a test tube and placed in

boiling water for 5 minutes. The test tube was then removed from the water, titled gently and curdling or clotting observed.

Non-Protein nitrogen:

The procedure as described by Ling (1956) was followed for NPN determination. 10 ml of well shaken milk sample was taken in a 50 ml flask and precipitated with 15 per cent trichlor-acetic acid upto the mark. The contents were filtered through Whatman No. 40 filter paper and the filterate collected in a dry flask. 20 ml of the filterate was transferred in a Kjeldahl flask and distilled with 75 ml of 50 per cent NaOH using N/10 H_2SO_4 in the receiving flask. Methyl red was used as indicator. After completing the distillation, the contents of the receiving flask were back-titrated against N/10 NaOH. End point reached when indicator turned yellow. The results were reported as per cent nitrogen in the sample.

Chilling and storage of samples:

The raw milk samples obtained in clean sterile bottles were chilled in two ways. Slow chilling by keeping in refrigerator and instantaneous chilling by immersing and

agetating in chilled water tank. Samples of fresh milk collected from dairy farm were chilled after 1, 2 and 3 hours exposure at room temperature. Chilled samples were then stored at 45°F, 72°F and room temperature. The shelf life of chilled milk samples stored at there temperatures was determined by making C.O.B. test at the end of 3 hr and onwards at 30 min intervals. Acidity was determined for the C.O.B. positive samples. The nonprotein nitrogen of the sample portion which turned C.O.B. positive first in the series of treatments given was also determined.

Determining effect of ambient temperatures on samples:

For shedy of ambient temperatures as a factor affecting quality of raw milk farm bulk milk was obtained from the dairy farm of the Rajasthan College of Agriculture, Udaipur. The shedy was made with special reference to summer months where room temperature ordinarily exceeds 30°C. The milk was exposed to identical temperatures as in summer in 1, 2 and 4 litres containers for 1, 2 and 3 hour as is the practice at collection centres of daries, in order to study the effect on the quality of raw milk. Temperature drop/ rise was recorded at the end of 1, 2 and 3 hour in each container. With every record of temperature samples from containers were drawn in clean sterile bottles

which were slowly/instantaneously chilled and stored at 45°, 72° and 90°F. The shelf life was determined by making C.O.B. and acidity tests. Containers made of brass, aluminium and clay were used in this study as used by producers supplying milk to centres. The raw chilled samples were also organoleptically tested before conducting C.O.B. test.

RESULTS

Evaluation of quality of raw milk:

For evaluating the quality of raw milk, 146 samples collected from three different sources, were examined. The chemical and bacterial tests included the one-hour resazurin test, the standard plate, coliform and the psychrophilic bacterial counts and determination of acidity and non-protein nitrogen.

One-hour resazurin test:

The data on the quality of raw milk as judged by the one-hour resazurin test are presented in Table I. The quality of farm milk was found to be better than the village and market milk.

TABLE I

Evaluation of quality of 146 samples of raw milk by one-hour resazurin test (*vide* Appendix-I)

Source of milk	No. of samples	No. (per cent) of samples in grade			
		Very good	Good	Fair	Poor
Dairy Farm	69	7(10.1)	50(72.4)	11(15.9)	1(1.4)
Rural collection centres	36	1(2.7)	3(8.3)	16(44.4)	16(44.4)
City market	46	11(26.8)	3(7.3)	12(29.2)	15(36.5)

Bacterial counts:

The bacteriological quality of the raw milk samples was evaluated by determining the standard plate, coliform and psychrophilic counts. The results are presented in Table II.

TABLE II

Averages and variations of bacterial counts in 146 samples of raw milk (*vide* Appendix-II)

Source of milk	No. of samples	Standard plate count/ml	Coliform count/ml	Psychrophilic count/ml
Dairy Farm	69			
Maximum		85000000	550000	100000000
Minimum		100000	100	170000
Average		5700000	32000	9710000
Rural Collection Centres	36			
Maximum		500000000	1000000	1000000000
Minimum		100000	10	900000
Average		117000000	130000	105000000
City Market	41			
Maximum		290000000	4400000	1000000000
Minimum		10000	10	25000
Average		23000000	435000	135000000

The bacterial counts of the milk samples were very high, especially in the rural collection and city market milk. There were wide variations in counts of individual samples of milk from all three sources.

Acidity and non-protein nitrogen:

The chemical tests used for determining the quality (freshness) of raw milk included the determination of acidity and non-protein nitrogen of samples. The results are presented in Table III.

TABLE III

Acidity and non-protein nitrogen content of 146 samples of raw milk (Appendix-III)

Source of milk	No. of samples	Percentage acidity	Mg non-protein nitrogen/ 100 g milk
Dairy Farm	69	0.119	17
Rural Collection Centres	36	0.103	10
City Market	41	0.077	7

The acidity in the market samples of milk was found to be very low as was the nonprotein nitrogen content of milk from that source.

Evaluation of quality of pasteurized milk:

For evaluating the quality of the pasteurized milk, 70 samples received from the Pilot Milk Supply Scheme were examined. Bacterial counts and acidity and non-protein nitrogen determinations were made on all samples.

Bacterial counts:

For evaluating the bacteriological quality of pasteurized milk, standard plate, coliform and psychrophilic counts were determined. The results are summerised in Table IV.

TABLE IV

Averages and variations of bacterial counts in 70 samples of pasteurized milk (*vide* Appendix IV)

Particulars	Standard plate count/ml	Coliform count/ml	Psychrophilic count/ml
Maximum	3,400,000	86,000	550,000
Minimum	15,000	1	10,000
Average	379,000	23,600	96,900

From the results presented in Table IV, it is clear that the quality of pasteurized milk used in the study was very poor.

Acidity and non-protein nitrogen:

The chemical tests used for evaluating the quality of pasteurized milk included the determination of acidity and non-protein nitrogen of samples. The results are presented in Table V.

TABLE V

Average acidity and non-protein nitrogen contents of 70 samples of pasteurized milk (*vide* Appendix V)

Percentage acidity	Mg non-protein N/100 g milk
0.088	12

Both the acidity and the non-protein nitrogen contents of the pasteurized milk samples were quite low, suggesting that there was no deterioration in the freshly processed milk.

Effect of ambient temperature exposure on quality of raw milk:

Type and size of containers: The effect of exposure of milk to ambient temperatures (90-97°F) in metal and clay containers of varying sizes was studied with fresh farm milk. The average temperature drop as noted in the study is presented in Table VI.

TABLE VI

Average temperature drop (°F) in milk stored at room temperature in metal and clay containers of different sizes (vide Appendix-VI)

Time of exposure/	Metal								
	Brass			Aluminium			Clay		
Size (litre)	1	2	4	1	2	4	1	2	4
(hr)									
1	3.3	4.1	4	2.7	5.3	3.0	3.4	4.0	3.0
2	6.3	6.0	8	8.5	6.0	3.0	7.5	6.3	4.8
3	10.0	9.0	10	6.2	9.5	2.7	7.6	6.0	10.8

The temperature drop was found to be gradual maximum temperature drop was recorded after 3 hours. In brass containers the temperature drop was the maximum.

Slow and instant-aneous chilling:

After recording the temperature of milk in different containers, samples were drawn to determine the keeping quality of fresh and exposed samples at ambient temperatures for 1, 2 and 3 hours followed by slow and instantaneous chilling and storage at 45° and 70°F was determined by using the C.O.B. test. The results on shelf life of the differently treated milk samples are presented in Table VII.

TABLE VII

Average shelf life of chilled samples of raw milk exposed to ambient temperatures for 1-3 hours (vide Appendix-VII)

Time of ambient exposure / Treatment	Shelf life (hr) and acidity percentage of milk stored at			
	45°F		70°F	
	Slowly chilled	Instantaneously chilled	Slowly chilled	Instant-aneously chilled
(hr)				
0	24.0 (0.18)	26.0 (0.15)	18.1 (0.17)	16.5 (0.18)
1	19.1 (0.17)	21.6 (0.16)	15.2 (0.17)	16.8 (0.18)
2	17.1 (0.18)	18.9 (0.17)	13.7 (0.16)	14.7 (0.18)
3	12.1 (0.17)	15.2 (0.17)	12.9 (0.17)	13.7 (0.17)

From the results presented in Table VII, the following observations could be made:

The instantaneously chilled samples of raw milk were found to keep longer than the slowly chilled. Exposure to ambient temperatures considerably reduced the shelf life of milk. Most samples became C.O.B. positive at an average acidity of 0.17 per cent.

Besides determining the shelf life of farm milk, shelf life of market and collection centre milk samples was also determined. The average shelf life of collection centres and city market samples after instantaneous chilling has been given in Table VIII.

TABLE VIII

Average shelf life of collection centre and city market samples of instantaneously chilled raw milk (vide Appendix-VIII)

Source of milk	Shelf life (hr) at	
	45°F	70°F
Rural collection centres	16.7	7.8
City Market	12.6	4.1

The shelf life of city market milk was comparatively shorter than the rural collection centre milk.

Evaluation of shelf life of pasteurised milk:

The keeping quality of samples of pasteurized and bottled milk stored at 45°, 72°F and room temperature was determined as presented in Table IX.

TABLE IX

Shelf life of pasteurized and bottled milk at different temperatures (*vide* Appendix-IX)

Particulars	Shelf life (hr) at		
	45°F	70°F	Room temperature
Maximum	75	23	11
Minimum	62	17	6
Average	68	19	9

The initial quality and the temperature of storage affected the shelf life of the samples of pasteurized milk.

DISCUSSION

Evaluation of quality of raw milk:

For efficient processing of fluid milk, it is essential to evaluate the quality of raw milk on receipt at the dairy. C.O.B. test is invariably made to accept or reject a patron's milk at the counter of milk plants. Other tests that may be made to determine the quality of milk are the one-hour resazurin test, standard plate, coliform and psychrophilic bacterial counts and the determination of acidity and non-protein nitrogen.

One-hour resazurin test:

In the present investigation 146 raw milk samples collected from three different sources were graded by one-hr resazurin test. The raw milk samples produced under clean conditions at the Rajasthan College of Agriculture Dairy Farm were graded as: very good (10.1 per cent), good (72.4 per cent), fair (15.9 per cent) and poor (1.4 per cent). Collection centre and city market samples were mostly found

to fall in poor catagory. Only 2.7 and 8.3 per cent samples of rural collection center milk were found to be of very good and good quality respectively while 44.4 per cent samples come under each of the fair and poor catagories. Of the city market samples, 26.8 per cent were graded very good, 7.3 per cent good, 29.2 per cent fair and 36.5 per cent poor.

The grading was done according to standards given by Laxminarayan (1946). Verma (1949) and Laxminarayana and Iya (1954) have also suggested tentative standards for grading Indian milks. According to these authors, satisfactory milk should not show pink or colourless shade in one-hour resazurin test and should have SPC of less than 1,000,000/ml.

Bacterial counts:

The standard plate, caliform and psychrophilic counts were found to vary considerably. The average bacterial content of farm milk was 5,700,000/ml, with a range of 100,000 - 85,000,000/ml. In rural collection centre milk the range was from 100,000 - 500,000,000/ml with average count of 117,000,000/ml, and in market samples the variation was from 10,000 - 290,000,000/ml. Thus majority of samples frim rural centres and city market were found to be of unsatisfactory

grade according to tentative standards suggested by Laxminarayana and Iya (1954). In Cairo (Egypt), Sadek and Hamed (1957) classified the milk into 3 grades: good, average and poor, with respective SPC of less than 1000,000/ml, 1000,000 - 10,000,000/ml and above 10,000,000/ml. Thomas et al. (1948) classified the samples into A, B, C grades with respective counts of less than 200,000/ml, 210,000 - 1,000,000/ml and above 1,000,000/ml. Naik (1950) suggested the adoption of scandinarian standards for grading milks as menioned below:

Counts/ml	Grade of milk	
Below 500,000	Class I	good
500,000 - 4,000,000	Class II	Fair
4,000,000 - 20,000,000	Class III	Poor
Above 20,000,000	Class IV	Very poor

For coliform count, Verma (1949) suggested a standard of 10,000/ml for village milk. In the present investigation the coliform counts varied from 100 - 550,000/ml with an average of 32,000/ml for farm milk, 10 - 1,000,000 with an average of 1,30,000/ml for collection centres milk and 10-4,400,000 with an average of 430,000/ml in market milk. Thus coliform incidence was high in farm milk and very high in collection centres and city market milk. Complete absence of coliform bacteria in farm produced raw milk as reported by Abd-el-Malik and Kirdany (1954), Thomas (1955) and Singh

(1964) was not found to comply with the results of the present investigation. High coliform counts in village collection centre and market milk were attributed to unhyginic conditions of born and animal and improper sterilization of utensils. Under hyginic and well organized conditions at IARI, Pusa, the milk was found to contain less than 10,000 bacterial/ml even during summer when the contamination was highest (Walton, 1925, 1927; Sci-rep, 1931-32).

The average coliform count of 130,000/ml in collection centre milk did not compare well with the averages reported by other workers for village milk in India (10,000/ml - Gopalkrishna and Laxminarayana, 1949).

The incidence of psychrophilic bacteria was also very high in the raw milk samples from all three sources. The psychrophiles ranged from 170,000 - 100,000,000/ml in farm milk, 900,000 - 1,000,000,000/ml in village collection centre milk and 25,000 - 1,000,000,000/ml in city market milk. The averages were 9,600,000; 94,000,000 and 135,000,000 per ml respectively. This unusually large number of psychrophilies may be considered to be from poorly sterilized utensils used for handling milk.

Jayashanker (1962) reported that psychrophilic counts were found to be very low for farm milk and very high for village milk. La Grange and Nelson (1961) found 26.5 per cent of raw milk samples to contain more than 1,000,000 psychrophiles/ml. Thomas et al. (1949) reported that 57.8 per cent of samples of raw milk had counts between 1,000 and 10,000,000/ml while 16.8 per cent contained less than, 1,000,000/ml they concluded that poorly sterilized utensils on farm were found to be source of psychrophilic bacteria. The high bacterial count was due to unhygienic conditions of milk, production, probable adultration with unclean water in market milk, and prolonged holding of milk at high atmospheric temperature at the collection centres.

Acidity and non-protein nitrogen:

The average acidity in farm, collection centre and market milk samples were 0.119, 0.103 and 0.077 per cent respectively. The farm milk had acidity near the normal (0.125 per cent, Jennes and Patton, 1959) while it was lower in village collection centre milk and much lower in market milk. This was probably due to adultration with water which considerably reduced acidity in market milk.

The average non-protein nitrogen content was also found to be much lower than the normal content of 23.0 mg/ 100 gm (Jennes and Patton, 1959). The average NPN content

was found to be 17, 10 and 7 mg respectively in farm, rural collection centres and market milk.

Evaluation of quality of pasteurized milk:

The quality of pasteurized milk of the samples used in the present study as revealed by the standard plate, coliform and psychrophilic counts did not conform to the standards prescribed by the U.S. Milk Ordinance and Code (1953). The presence of large number of coliform and psychrophilic organisms in samples used in present study indicated post-pasturization contamination and poor plant saniation. The coliform bacteria did not confirm American and British standards of less than 10/ml in pasteurized milk. The psychrophilic counts did not confirm to these to those reported by other workers (Thomas and Chandrasakher, 1946, and Kennedy and Weiser, 1959).

Chemical tests:

The average acidity and non-protein nitrogen contents were found to be 0.088 per cent and 12 mg/100 gm milk. It was observed that heating of milk reduced acidity, while the NPN content remained unaffected.

Effect of ambient temperature exposure on quality of raw milk:

Type of container: The temperature drop recorded in milk in containers of brass, aluminium and clay after 1, 2 and 3 hours was found to be gradual. In brass containers of all three sizes, the temperature drop was the maximum. Also after 3 hours exposure maximum temperature drop was recorded. However, the variation was not so great in metal and clay containers. The ambient temperature exposure was found to be an important factor in affecting temperature and quality of milk.

Slow and instantaneous chilling:

The raw milk, fresh and exposed, was stored for judging the keeping quality at 45° and 70°F after slow and instantaneous chilling. The shelf life was found to be maximum for fresh, instantaneously chilled raw milk and minium for the samples exposed at ambient temperatures for 3 hours. As shown in the results, the keeping quality of slowly chilled samples held at 40°F after ambient temperature exposed for 0, 1, 2 and 3 hours was 24, 19.1, 17.1 and 12.1 hr, respectively. In case of the instantaneously chilled milk it was 26, 21.6, 18.9 and 15.2 hr, respectively. The average acidity at C.O.B. end point was found to vary from 0.15 to

0.18 per cent with most samples curdling at an average acidity of 0.17 per cent.

The shelf life was reduced considerably at 70°F. At this temperature, the difference in average shelf life of slowly and instentaneously chilled milk was found to be small, ½ to 1½ hr. Fresh, instantaneously chilled row milk had shelf life shorter than slowly chilled milk at 70°F. Instantaneously chilled rural collection centres and city market milk samples had a shelf life of 16.7 and 17.6 hr at 45°F, and of 7.8 and 4.1 hr at 70°F respectively.

Clot-on-boiling test was used as the test indicating shelf life. Acidity was determined of COB positive samples. The average NPN content of some of the samples which were first to become COB positive was found to be 14.2 mg and 14.4 mg respectively for slowly and instantaneously chilled milks.

It was found that the keeping quality of raw chilled milk samples was 2-3 times less than pasteurized milk samples stored at low temperatures. As the temperature was raised the keeping quality was reduced. The result were similar to those reported by Nicholas and Anderson (1942), Swortling (1953), Alexander et al. (1953) and Ellingsen(1961)

for pasteurized milk. Gunney et al. (1950) found a process of heating and then cooling to 40°F better than cooling alone at 40°, 50° and 60°F for milks exposed to atmospheric temperature from 74-98.6°F. The forme process was reported to double the marketable life of row milk.

Evaluation of shelf life of pasteurized milk:

The keeping quality of pasteurized milk stored at 45°, 70°F and at room temperature did not exceed 75, 23 and 11 hr respectively. Minimum storage life of 62, 17 and 6 hr respectively was attributed to poor plant sanitation which ultimately affected the bacteriological quality of pasteurizes milk. The average shelf life was 69, 19 and 9 hr respectively. Shelf life at 45°F was found to be almost similar to that obtained by Weese and Handerson (1949). They reported a keeping quality of 3-4 days in home refrigirator. The pasteurized milk was reported to undergo spoilage within 12-20 hr at atmospheric temperatures (30-37°C) by Iya (1964). The reduction in keeping quality of commercially pasteurized milk was reported to be related to coliform count (Piraux et al., 1953). Post-pasteurization contamination was considered more important than original flora of milk in determing

keeping quality of commercially pasteurized milk (Meyknett and Dam, 1957; Storgards, 1958; Cronshaw, 1947). Reduction in the keeping quality time between 1½ to 6 days has been reported to occur as a result of post-pasteurization contamination (Egdell, et al., 1949; Swartling, 1953 and Thome et al., 1957).

SUMMARY AND CONCLUSION

With a view to assess the feasibility of marketing raw chilled milk, instead of pasteurised milk, 146 samples of raw milk obtained from divergent sources - organized dairy farm, rural collection centres of processing plant and city market-were examined. The effect of ambient temperature exposure of raw milk chilled slowly and instantaneously for 1, 2 and 3 hr on its shelf life at 45° and 70°F was determined. The shelf life for the ambient temperature exposed (0, 1, 2 and 3 hr) and slowly chilled raw milk was 24.0, 19.1, 17.1 and 12.1 hr at 45°F, and 18.1, 15.2, 13.7 and 12.9 hr at 70°F. For instantaneously chilled milk it was 26.0, 21.6, 18.9 and 15.2 hr at 45°F and 16.5, 16.8, 14.7 and 13.7 hr at 70°F. The shelf life of 21 samples of pasteurised bottled milk was also evaluated at 45°, 70°F and room temperature. These samples were analysed for the one-hr resazurin test, standard plate, coliform and psychrophilic counts and acidity and non-protein nitrogen contents.

The procedures described in the standard methods for the examination of dairy products (1960), Chalmers (1955)

and Ling (1957) were followed with slight changes as mentioned in the chapter on Materials and Methods of this manuscript.

According to the one-hr resazurin test, 82.7 per cent samples of dairy farm, 11.2 per cent samples of rural collection centres and 34.3 per cent samples of the city market milk were found satisfactory. A very high incidence of coliform and psychrophilic bacteria was also observed in rural collection centre and city market milk. The acidity and non-protein nitrogen contents of the raw milk used in this study were found to be normal to below normal.

The quality of pasteurized milk as judged by bacterial counts was found to be poor. The acidity and the non-protein nitrogen content of the pasteurized milk were also quite low.

The shelf life of pasteurized bottled milk at 45°F, 70°F and room temperature was found to be 68, 19 and 9 hr respectively.

From the results of the present study it may be concluded that because of the unhyginic conditions of the

milk production in villages and the high temperature holding, the quality of both raw and pasteurized milk was very poor. The shelf life of the high count pasteurized milk was also found to be considerably shorter to enable the returned milk to be rechilled or repasteurized for redistribution as fluid milk. Since the raw milk exposed to ambient temperatures for 0-3 hr could be held for a reasonably long period after slow or instantaneous chilling, the findings of the present study suggest the possibility of marketing good quality raw chilled milk without pasteurization.

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APPENDIX-I

Evaluation of quality of 146 samples of raw milk by one-hour resazurin test

Sample No.	Colour shade	Sample No.	Colour shade
1	Pink	31	Mauve
2	Pink mauve	32	Pink mauve
3	Pink mauve	33	Pink mauve
4	Pink mauve	34	Pink mauve
5	Pink mauve	35	Pink mauve
6	Pink mauve	36	Pink mauve
7	Pink mauve	37	Pink mauve
8	Pink mauve	38	Pink mauve
9	Pink mauve	39	Pink mauve
10	Pink mauve	40	Mauve pink
11	Pink mauve	41	Pink mauve
12	Pink mauve	42	Pink
13	Pink mauve	43	Pink
14	Pink mauve	44	Pink
15	Pink mauve	45	Pink
16	Mauve	46	Pink mauve
17	Pink mauve	47	Pink mauve
18	Pink mauve	48	Pink mauve
19	Pink mauve	49	Pink mauve
20	Mauve	50	Pink mauve
21	Pink mauve	51	Pink mauve
22	Pink mauve	52	Pink mauve
23	Pink mauve	53	Pink mauve
24	Pink mauve	54	Pink mauve
25	Mauve	55	Pink mauve
26	Mauve	56	Pink mauve
27	Mauve	57	Pink mauve
28	Pink	58	Pink mauve
29	Pink mauve	59	Pink
30	Pink	60	Pink

Contd.... (ii)

Sample No.	Colour shade	Sample No.	Colour shade
61	Mauve pink	66	Mauve pink
62	Pink	67	Mauve pink
63	Pink	68	Pink
64	Pink	69	Colourless
65	Pink		

Rural collection centres:

1	Pink	19	Pink
2	Colourless	20	Pink
3	Pink	21	Pink
4	Colourless	22	Pink
5	Pink	23	Pink
6	Colourless	24	Colourless
7	Colourless	25	Colourless
8	Pink	26	Pink
9	Colourless	27	Pink
10	Colourless	28	Pink
11	Colourless	29	Pink mauve
12	Colourless	30	Pink
13	Colourless	31	Pink mauve
14	Colourless	32	Pink
15	Colourless	33	Mauve
16	Colourless	34	Pink
17	Colourless	35	Pink mauve
18	Pink	36	Colourless

Market samples:

1	Colourless	6	Colourless
2	Pink	7	Colourless
3	Pink	8	Colourless
4	Mouve pink	9	Pink
5	Pink mouve	10	Pink

Contd.... (iii)

Sample No.	Colour shade	Sample No.	Colour shade
11	Pink	27	Colourless
12	Pink	28	Colourless
13	Pink mauve	29	Colourless
14	Pink	30	Colourless
15	Colourless	31	Blue
16	Colourless	32	Blue
17	Pink	33	Blue
18	Colourless	34	Blue
19	Pink	35	Blue
20	Pink	36	Blue
21	Pink	37	Blue
22	Pink	38	Blue
23	Colourless	39	Blue
24	Colourless	40	Blue
25	Colourless	41	Blue
26	Colourless		

APPENDIX-II

Bacterial counts in 146 samples of raw milk

Sample No.	SPC/ml	C.C./ml	PBC/ml
Farm milk:			
1	350,000	130	760,000
2	230,000	150	2,000,000
3	280,000	140	2,200,000
4	250,000	3,000	410,000
5	280,000	2,500	1,900,000
6	160,000	4,300	950,000
7	540,000	2,700	380,000
8	260,000	3,000	170,000
9	380,000	3,100	1,400,000
10	4,100,000	160,000	10,000,000
11	3,400,000	10,000	10,000,000
12	5,000,000	6,700	10,000,000
13	3,200,000	4,500	10,000,000
14	2,500,000	15,000	8,400,000
15	3,000,000	1,300	11,000,000
16	5,600,000	1,600	790,000
17	240,000	2,900	780,000
18	590,000	4,600	4,700,000
19	570,000	1,700	6,000,000
20	3,100,000	6,800	2,900,000
21	1,800,000	5,500	57,000,000
22	930,000	150,000	100,000,000
23	1,300,000	470,000	100,000,000
24	680,000	140,000	48,000,000
25	1,700,000	100	440,000
26	2,100,000	100	600,000
27	1,700,000	100	2,800,000
28	2,200,000	65,000	920,000
29	1,400,000	80,000	380,000
30	1,600,000	47,000	3,400,000

Sample No.	SPC/ml	CC/ml	FBC/ml
31	3,800,000	15,000	3,400,000
32	6,200,000	5,100	5,800,000
33	3,100,000	1,100	2,600,000
34	4,400,000	20,000	5,000,000
35	6,300,000	1,100	10,000,000
36	14,000,000	550,000	16,000,000
37	3,300,000	4,200	4,000,000
38	4,300,000	3,100	6,100,000
39	1,900,000	900	2,600,000
40	3,700,000	140,000	1,000,000
41	3,900,000	3,000	5,000,000
42	3,100,000	38,000	4,300,000
43	810,000	2,500	610,000
44	540,000	3,900	340,000
45	19,000,000	12,000	5,600,000
46	10,000,000	1,200	41,000,000
47	3,400,000	1,800	1,800,000
48	2,000,000	1,000	1,400,000
49	2,900,000	25,000	3,800,000
50	6,200,000	16,000	1,100,000
51	5,400,000	4,000	12,000,000
52	2,10,0000	3,200	590,000
53	2,800,000	5,700	1,100,000
54	3,200,000	800	1,700,000
55	100,000	1,200	540,000
56	2,300,000	1,000	420,000
57	3,000,000	1,000	3,500,000
58	17,000,000	12,000	3,400,000
59	82,000,000	48,000	9,800,000
60	85,000,000	30,000	16,000,000
61	3,800,000	15,000	20,000,000
62	5,900,000	4,500	30,000,000
63	8,800,000	2,800	24,000,000
64	3,300,000	4,400	4,500,000
65	4,700,000	5,300	4,000,000
66	2,100,000	6,200	4,000,000
67	2,500,000	4,800	5,800,000
68	3,100,000	5,700	7,300,000
69	7,200,000	5,700	9,900,000
Average	5,700,000	32,000	9,710,000

Sample No.	SPC/ml	CC/ml	PBC/ml
Rural collection centre:			
1	18,000,000	220,000	130,000,000
2	8,100,000	320,000	35,000,000
3	18,000,000	800	2,800,000
4	13,000,000	90,000	3,600,000
5	12,000,000	11,000	1,900,000
6	29,000,000	6,200	53,000,000
7	77,000,000	3,700	3,200,000
8	900,000	10	2,600,000
9	500,000,000	1,700	20,000,000
10	500,000,000	1,300	1,900,000
11	500,000,000	3,000	2,100,000
12	500,000,000	500	2,400,000
13	500,000,000	9,500	8,500,000
14	4,900,000	4,500	4,200,000
15	26,000,000	92,000	13,000,000
16	7,200,000	5,100	6,400,000
17	100,000,000	1,4000	65,000,000
18	2,700,000	2,400	1,500,000
19	500,000,000	32,000	500,000
20	5,100,000	7,700	900,000
21	500,000,000	6,500	23,000,000
22	18,000,000	1,000,000	1,000,000,000
23	43,000,000	1,000,000	1,000,000,000
24	12,000,000	400,000	400,000,000
25	6,500,000	170,000	28,000,000
26	9,300,000	1,300	17,000,000
27	120,000,000	100,000	500,000,000
28	85,000,000	[illegible],000	120,000,000
29	47,000,000	800,000	180,000,000
30	29,000,000	2,300	17,000,000
31	6,000,000	11,000	24,000,000
32	3,000,000	10	15,000,000
33	100,000	7,500	15,000,000
34	4,300,000	22,000	20,000,000
35	4,700,000	160,000	22,000,000
36	100,000	10	97,000,000
Average	117,000,000	130,000	105.000.000

Sample No.	SPC/ml (0000)	CC/ml	PBC/ml (000)
City market:			
1	120	250,000	240,000
2	90	12,000	90,000
3	130	8,000	180,000
4	1200	10	240,000
5	480	110,000	360,000
6	1600	4,400,000	230,000
7	3400	100	130,000
8	1400	4,000,000	1,000,000
9	1040	3,800,000	1,50,000
10	850	100	89,000
11	80	54,000	56,000
12	300	87,000	84,000
13	600	29,000	78,000
14	530	38,000	96,000
15	240	480,000	198,000
16	600	680,000	43,000
17	1500	92,000	69,000
18	190	7,000	40,000
19	180	440,000	300,000
20	900	180,000	58,000
21	550	3,000,000	75,000
22	490	19,000	46,000
23	28900	22,000	130,000
24	12000	42,000	130,000
25	11000	29,000	49,000
26	2800	6,000	52,000
27	20000	8,000	190,000
28	2500	2,000	19,000
29	1	3,000	42,000
30	800	2,000	37,000

contd....(viii)

Sample No.	SPC/ml (0000)	CC/ml	PBC/ml (000)
31	28	460	16
32	22	380	220
33	300	790	120
34	300	1,000	220
35	14	1,100	25
36	52	360	230
37	17	1,200	260
38	13	1,400	110
39	34	1,500	760
40	17	1,800	850
41	50	540	3,100
Average	2,300	435,000	135,000

APPENDIX-III

Acidity and non-protein nitrogen content of 146 samples of raw milk

Sample No.	% acidity	NPN mg/ 100 gm	Sample No.	% acidity	NPN mg/ 100 gm
Dairy farm:					
1	0.13	12	31	0.12	13
2	0.13	16	32	0.13	12
3	0.13	12	33	0.12	13
4	0.11	12	34	0.10	13
5	0.12	16	35	0.11	13
6	0.11	16	36	0.10	13
7	0.11	15	37	0.10	13
8	0.13	16	38	0.10	9
9	0.10	13	39	0.11	15
10	0.10	15	40	0.13	19
11	0.11	16	41	0.12	12
12	0.10	16	42	0.15	12
13	0.12	16	43	0.12	11
14	0.12	19	44	0.12	9
15	0.12	23	45	0.13	11
16	0.12	16	46	0.11	8
17	0.12	19	47	0.12	12
18	0.12	20	48	0.11	19
19	0.12	12	49	0.12	9
20	0.14	13	50	0.12	5
21	0.13	16	51	0.11	15
22	0.11	16	52	0.10	5
23	0.11	19	53	0.11	19
24	0.11	15	54	0.11	8
25	0.12	13	55	0.11	13
26	0.12	19	56	0.12	19
27	0.12	13	57	0.12	15
28	0.13	12	58	0.12	33
29	0.09	12	59	0.14	11
30	0.15	15	60	0.14	33

Sample No.	% acidity	NPN mg/ 100 gm	Sample No.	% acidity	NPN mg/ 100 gm
61	0.12	27	66	0.12	11
62	0.14	12	67	0.13	12
63	0.14	36	68	0.12	12
64	0.13	13	69	0.12	13
65	0.14	12			
Average for 69 samples				0.119	17
Collection centres:					
1	0.08	11	19	0.12	8
2	0.11	15	20	0.13	13
3	0.08	9	21	0.10	8
4	0.10	8	22	0.09	6
5	0.11	11	23	0.11	6
6	0.12	8	24	0.09	6
7	0.12	11	25	0.08	6
8	0.09	11	26	0.10	9
9	0.10	12	27	0.11	11
10	0.13	13	28	0.09	8
11	0.12	13	29	0.11	11
12	0.12	16	30	0.10	9
13	0.10	16	31	0.08	6
14	0.08	15	32	0.12	15
15	0.09	13	33	0.11	13
16	0.11	8	34	0.08	16
17	0.12	9	35	0.09	15
18	0.12	11	36	0.12	13
Average for 36 samples				0.103	10

Sample No.	% acidity	NPN mg/ 100 gm	Sample No.	% acidity	NPN mg/ 100 gm
1	0.06	6	21	0.05	6
2	0.07	6	22	0.06	4
3	0.06	8	23	0.06	4
4	0.11	11	24	0.05	1
5	0.10	11	25	0.07	4
6	0.12	13	26	0.05	1
7	0.11	12	27	0.07	5
8	0.08	9	28	0.05	4
9	0.09	9	29	0.05	4
10	0.10	11	30	0.06	1
11	0.07	8	31	0.05	11
12	0.09	8	32	0.06	8
13	0.10	11	33	0.07	9
14	0.10	5	34	0.06	6
15	0.05	1	35	0.05	9
16	0.13	1	36	0.06	9
17	0.12	5	37	0.07	9
18	0.08	1	38	0.05	11
19	0.11	1	39	0.05	11
20	0.11	1	40	0.07	6
			41	0.05	12
Average for 41 samples				0.077	7

APPENDIX-IV

Bacterial counts in 70 samples of pasteurized milk

Sample No.	SPC/ml (000)	CC/ml	PBC/ml (000)	Sample No.	SPC/ml (000)	CC/ml	PBC/ml (000)
1	33	20	120	36	25	650	25
2	150	29	32	37	33	120	32
3	19	145	78	38	26	100	34
4	21	1900	67	39	3400	1600	29
5	33	1500	27	40	450	350	260
6	23	86000	550	41	830	29	29
7	58	250	40	42	690	150	24
8	110	100	43	43	800	21	16
9	15	10	39	44	530	5200	250
10	130	250	31	45	440	180	330
11	120	410	37	46	300	8900	160
12	1400	120	89	47	250	3800	410
13	2500	90	230	48	110	850	42
14	1900	240	110	49	89	20	15
15	3100	420	40	50	19	20	18
16	2500	7000	78	51	381	50	28
17	2500	29000	20	52	32	400	64
18	120	250	320	53	45	340	62
19	86	120	280	54	30	510	22
20	53	1	45	55	51	300	52
21	21	300	48	56	24	180	12
22	110	1	17	57	150	290	69
23	100	1	120	58	36	220	85
24	57	17	130	59	38	280	60
25	130	17	48	60	92	680	88
26	59	25	32	61	33	29	120
27	21	40	46	62	150	52	89
28	17	39	34	63	110	29	78
29	35	87	160	64	83	4300	120
30	100	57	320	65	79	3700	18
31	74	43	170	66	42	4100	10
32	210	21	240	67	56	39	18
33	50	14	63	68	57	46	17
34	240	26	120	69	23	19	27
35	260	17	200	70	28	25	46
Average of 70 samples					379	23600	97

APPENDIX-V

Acidity and non-protein nitrogen contents of 70 samples of pasteurized milk

Sample No.	% acidity	NPN mg/ 100 gm	Sample No.	% acidity	NPN mg/ 100 gm
1	0.09	11	36	0.10	13
2	0.08	12	37	0.09	15
3	0.10	12	38	0.09	12
4	0.10	13	39	0.08	8
5	0.09	9	40	0.08	11
6	0.10	9	41	0.08	11
7	0.07	9	42	0.09	6
8	0.09	11	43	0.09	19
9	0.10	12	44	0.10	27
10	0.10	11	45	0.08	18
11	0.08	13	46	0.08	12
12	0.09	13	47	0.09	9
13	0.09	8	48	0.08	11
14	0.09	12	49	0.08	6
15	0.09	11	50	0.09	19
16	0.10	8	51	0.08	5
17	0.09	15	52	0.08	8
18	0.09	13	53	0.09	9
19	0.10	9	54	0.09	8
20	0.09	11	55	0.09	13
21	0.10	15	56	0.09	6
22	0.10	11	57	0.10	19
23	0.08	12	58	0.08	22
24	0.09	8	59	0.09	30
25	0.10	9	60	0.08	9
26	0.08	11	61	0.09	19
27	0.10	11	62	0.09	13
28	0.10	9	63	0.08	9
29	0.09	11	64	0.08	12
30	0.09	8	65	0.08	13
31	0.09	11	66	0.09	15
32	0.08	11	67	0.09	15
33	0.09	9	68	0.09	16
34	0.08	8	69	0.09	15
35	0.08	11	70	0.08	15
Average of 70 samples				0.088	12

APPENDIX-VI

Temperature drop (°F) in milk stored at room temperature in metal and clay containers of different sizes

	Metal						Clay		
	Brass			Aluminium					
Size Lit.	1	2	4	1	2	4	1	2	4
1 hour									
	8	7	5	4	7	6	6	10	4
	2	6	4	2	12	4	2	4	0
	3	6	4	2	8	0	7	3	1
	4	1	3	3	2	3	0	3	5
	2	4	4	3	3	3	2	4	4
	2	4	4	-	2	2	-	0	4
	2	2	-	-	3	-	-	-	-
	-	3	-	-	-	-	-	-	-
Av.	3.3	4.1	4	2.7	5.3	3	3.4	4	3
2 hours									
	7	6	8	4	5	4	6	12	6
	8	10	10	13	16	4	10	6	10
	14	8	6	18	4	2	15	8	6
	11	2	-	12	5	0	10	5	1
	2	6	-	12	3	3	6	4	1
	3	4	-	6	3	5	6	6	5
	4	-	-	2	-	-	0	3	-
	6	-	-	4	-	-	-	-	-
	3	-	-	4	-	-	-	-	-
	5	-	-	2	-	-	-	-	-
Av.	6.3	6	8	8.5	6	3	7.5	6.3	4.8
3 hours									
	10	9	10	9	9	6	10	7	9
	10	10	11	8	10	2	10	6	14
	11	8	9	4	11	2	12	6	9
	9	-	-	4	8	1	2	5	-
	-	-	-	-	-	-	4	-	-
Av.	10	9	10	6.2	9.5	2.7	7.6	6	10.8

APPENDIX-VII

Shelf life of chilled samples of raw milk exposed to ambient temperature for 1-3 hours

Slowly chilled				Instantaneously chilled			
45°F	70°F	% acidity		45°F	70°F	% acidity	
Fresh							
24	16.5	0.19	0.15	26	15.0	0.15	0.16
24	16.5	0.17	0.19	26	15.0	0.15	0.18
25	14.0	0.18	0.18	27	16.0	0.15	0.17
23	15.0	0.17	0.18	26	16.0	0.15	0.20
24	15.0	0.19	0.19	25	13.0	0.15	0.18
4	18.0	-	0.16	-	18.0	-	0.19
22	22.0	-	0.15	-	22.5	-	0.18
Av.24	18.1	0.18	0.17	26	16.5	0.15	0.18
1 hour							
15	16.0	0.18	0.16	26.0	18.0	0.20	0.16
24	14.0	0.18	0.14	24.0	11.5	0.18	0.14
16	15.5	0.17	0.16	24.0	21.0	0.19	0.14
18	19.0	0.19	0.16	19.5	21.0	0.18	0.18
18	18.0	0.20	0.17	19.5	21.0	0.19	0.17
18	18.5	0.17	0.18	21.0	23.0	0.20	0.18
19	10.0	0.18	0.19	23.0	10.5	0.17	0.16
18	9.5	0.17	0.17	21.0	10.0	0.16	0.19
17	10.0	0.18	0.17	22.0	11.0	0.16	0.20
18	17.0	0.21	0.17	22.0	17.5	0.17	0.17
18	-	0.20	-	22.0	-	0.16	-
25	-	0.20	-	22.0	-	0.17	-
25	-	0.20	-	22.0	-	0.17	-
13	-	0.17	-	13.5	-	0.19	-
13.5	-	0.17	-	13.5	-	0.18	-
14	-	0.16	-	15.5	-	0.15	
14	-	0.18	-	15.5	-	0.15	-
24	-	0.16	-	27.0	-	0.16	-
23	-	0.14	-	28.0	-	0.14	-
23.5	20.00	0.18	0.19	24.0	21.5	0.17	0.19
Av.19.1	17.5	0.17	0.17	21.6	16.8	0.16	0.18

Appendix-VII continued

Slowly chilled				Instantaneouslu chilled			
45°F	70°F	% acidity		45°F	70°F	% acidity	
2 hours							
15.0	17.0	0.16	0.18	16.0	22.0	0.20	0.19
16.0	18.0	0.19	0.15	15.5	23.0	0.19	0.17
15.5	18.5	0.20	0.15	15.5	21.0	0.19	0.19
21.0	12.0	0.17	0.18	15.0	11.0	0.14	0.17
21.0	12.0	0.18	0.17	15.0	11.0	0.14	0.20
15.0	13.0	0.15	0.19	24.0	11.0	0.15	0.18
24.0	9.0	0.16	0.16	21.0	10.0	0.18	0.16
12.5	8.5	0.17	0.19	22.5	9.0	0.17	0.20
21.0	15.5	0.18	0.15	22.5	15.0	0.16	0.17
21.0	-	0.18	-	24.0	-	0.17	-
17.0	-	0.19	-	20.0	-	0.18	-
17.5	-	0.19	-	19.5	-	0.21	-
18.0	-	0.22	-	23.5	-	0.18	-
18.0	-	0.21	-	23.5	-	0.17	-
17.0	-	0.20	-	23.5	-	0.16	-
22.0	-	0.20	-	25.5	-	0.18	-
21.0	-	0.19	-	25.0	-	0.18	-
9.5	-	0.18	-	9.5	-	0.17	-
9.5	-	0.17	-	9.5	-	0.17	-
11.5	-	0.16	-	12.5	-	0.17	-
11.5	-	0.18	-	11.5	-	0.18	-
24.0	-	0.16	-	24.0	-	0.18	-
Av. 17.1	13.7	0.18	0.16	18.9	14.7	0.18	0.17

Slowly chilled				Instantaneously chilled			
45°F	70°F	% acidity		45°F	70°F	% acidity	
3 hours							
6.0	16.0	0.18	0.15	10.0	20.0	0.17	0.15
6.0	18.0	0.20	0.15	9.5	21.5	0.18	0.17
6.0	16.0	0.20	0.20	10.5	18.0	0.17	0.15
8.5	16.0	0.18	0.19	10.0	18.5	0.19	0.19
7.5	16.5	0.18	0.19	10.0	19.0	0.19	0.20
8.5	12.5	0.20	0.16	10.0	11.0	0.19	0.20
8.0	12.5	0.16	0.15	12.5	11.0	0.17	0.16
8.0	11.5	0.16	0.20	12.5	10.5	0.18	0.16
11.0	11.0	0.16	0.17	14.5	10.0	0.18	0.20
8.50	11.0	0.17	0.18	13.5	10.5	0.18	0.19
11.0	7.0	0.15	0.20	14.5	7.0	0.16	0.19
11.0	7.5	0.18	0.21	14.5	7.5	0.16	0.18
13.0	-	0.17	-	10.5	-	0.16	-
12.0	-	0.17	-	9.5	-	0.17	-
15.0	-	0.17	-	18.0	-	0.16	-
15.5	-	0.18	-	21.5	-	0.16	-
16.5	-	0.16	-	17.5	-	0.15	-
15.0	-	0.17	-	18.0	-	0.16	-
14.5	-	0.16	-	19.0	-	0.16	-
22.0	-	0.15	-	27.0	-	0.16	-
21.0	-	0.16	-	27.0	-	0.17	-
21.5	-	0.16	-	26.0	-	0.18	-
Av. 12.1	12.9	0.17	0.176	15.2	13.7	0.17	0.178

APPENDIX-VIII

Shelf life of instantaneously chilled rural collection centre and city market samples of raw milk in hours

Sample No.	Market sample shelf life at		Sample No.	Village sample shelf life at	
	45°F	70°F		45°F	70°F
1	9.0	6.0	1	-	19.5
2	8.0	6.0	2	-	20.5
3	8.5	6.5	3	-	19.5
4	9.0	5.0	1	-	19.5
5	9.5	5.0	2	-	22.5
6	4.0	2.0	3	-	20.5
2	5.0	1.5	1	23.5	9.0
3	4.0	2.0	2	20.0	9.5
4	4.5	2.0	3	21.0	9.0
5	5.0	3.0	4	19.0	10.0
6	5.5	2.5	5	21.0	10.0
7	4.0	1.5	6	19.0	10.5
8	3.5	1.0	7	18.0	11.0
			8	19.5	11.5
1	7.0	4.0	9	21.0	10.0
2	9.0	5.0	10	20.5	11.0
3	10.0	5.0			
4	8.0	3.5	1	16.0	6.0
5	7.5	3.0	2	16.0	6.5
6	9.0	4.0	3	17.5	6.0
7	8.0	5.0	4	16.0	7.0
8	9.5	4.5	5	17.0	7.0
9	9.5	4.5	6	17.0	7.0
10	10.0	5.0	7	16.0	6.0
11	1110	6.0	8	17.5	5.0
12	10.0	4.5	9	18.0	6.0
13	8.0	3.5	10	18.0	7.0
14	6.0	2.0			
15	7.5	3.0	1	12.0	7.0
16	8.0	4.8	2	15.0	6.0
17	8.5	4.0	3	14.0	7.5
			4	13.0	8.0
1	20.0	9.5	5	13.0	7.5
2	18.0	14.5	6	12.0	6.0
3	19.5	10.0	7	10.0	6.0
4	20.5	15.0	8	10.5	5.5
5	23.0	13.0	9	14.0	6.5
6	25.0	14.0			
7	26.0	17.5			
8	25.5	18.0			
9	27.0	18.0			
10	26.0	13.5			
11	19.5	12.0			
Average	12.6	4.1		16.7	7.8

APPENDIX-IX

Self life of pasteurized and bottled milk at different temperatures

Sample No	Time (hr) after which milk curdled		
	45°F	72°F	Room temperature
1	68	17	8
2	70	21	10
3	58	22	8
4	68	18	8
5	70	18	9
6	72	70	10
7	75	20	11
8	75	20	11
9	76	17	11
10	69	18	9
11	62	18	8
12	60	19	8
13	63	19	6
14	63	18	10
15	64	18	11
16	73	17	11
17	75	21	9
18	74	23	8
19	60	19	9
20	65	20	6
21	60	21	8
Average	68 hr	19 hr	9 hr