CHAPTER 4

DISCUSSION AND CONCLUSIONS

As a result of the deregulation of the milk industry, milk-shops have become a common retail outlet for the sale of fresh milk over the past few years. This study aimed to determine the quality of milk available to the consumer, and to look at whether or not there was a difference between milk sold from milk-shops and milk sold by a large national distributor. In addition, the milk bought from both the milk-shops and the national distributor was also analysed to see whether it contained selected public health hazards.

The study showed that milk-shop milk quality differed significantly ($p < 0.05$) from the milk which originated from the national distributor and varied greatly between milk-shops and between sampling days over the six-week period. Milk from the national distributor showed minimal variation and was always well within the parameters laid down by law.

Price of the Milk

One of the deciding factors for the consumer on whether to purchase milk from a milk-shop or not, is the price of milk. The price of milk-shop milk should be lower than milk from other sources as the cost of packaging is excluded when consumers use their own containers.

The price of the pre-packaged milk-shop milk varied from R2.80 to R3.40 per litre (a 20% difference in the price), which was more expensive than the sachets from the national distributor, which varied between R2.85 and R2.90 per litre. Had the milk however, been purchased directly from the bulk tank, it would have been on average about R0.60 to R0.80 cheaper, as the cost of the container would then be eliminated. This would work out at about a 25% to 33% reduction in cost, and would make it cheaper than the national distributor's

milk. For the consumer this would be one of the benefits of purchasing milk from milk-shops, as a lot of money could be saved over time, providing they used their own containers.

Temperature of the Milk at Purchase

The storage temperature and maintenance of the cold chain is an important factor that influences the safety and keeping quality of milk, especially in a country with warm climatic conditions like South Africa. To delay the growth of micro-organisms, it is recommended to hold the milk at ≤5°C (Lück 1986). Lück *et al.* (1977) report that studies have shown that when the storage temperature is increased to 7°C the standard plate count of a milk sample after 7 days may be as much as 1 000 times higher than on a comparable sample stored at 4°C to 5°C. In another article, Gruetzmacher & Bradley (1999) cite several authors who found that a 3°C rise in temperature decreases the shelf-life of milk by one half. Even at 0°C to 2°C the total bacterial count of milk can increase significantly after 2 days, especially when the initial bacterial count is high (Lück 1986). The normal cold chain can, however, only contribute to a limited improvement of the shelf-life of pasteurised milk (or any other perishable dairy product) when the products contain large numbers of post-processing contaminants which grow at cold chain temperatures (Lück 1986). At elevated temperatures the growth of pathogenic organisms such as *S. aureus, Bacillus* spp., enterotoxin-producing *E. coli* and others is increased and therefore these can cause health hazards (Lück 1986).

Samples taken by Lück (1986) in South Africa showed that the temperature of pasteurised milk in display cabinets in supermarkets in different towns ranged from 0°C to 12°C and varied by 0.3°C to 6.4°C within the display cabinets. Seventy-one percent of 76 samples of pasteurised milk collected from different supermarkets exceeded the bacteriological standards laid down by the regulations at that time, one of the main reasons probably being failure to maintain the cold chain (Lück 1986). In this study, it was not possible to take temperatures inside the shop as this would have created suspicion. Therefore the temperature was taken as soon as possible after purchase, and at least within five minutes of purchase, to prevent a rise in the temperature due to environmental conditions. If there was a slight increase in

temperature in the time between purchase and measurement, it would have been a systematic error throughout all the samples. To overcome the possibility of contaminating the milk, 100 mℓ was decanted and used to take the temperature. The results showed that 73.4% of milk samples were kept at a temperature above 5°C. These high temperatures undoubtably influenced the aerobic standard plate count, the psychrotrophic bacterial count and the coliform count (see later). The highest aerobic standard plate counts were found in Milk-shop 4 whose temperatures varied from 6.5°C to 11°C with none of the milk ever being below 5°C. Temperatures also varied in the display cabinet or refrigerators as two samples were purchased from each shop on a particular day, and 50% of these did not always have the same temperature. Taking into account the literature on the effect of temperature on bacterial counts, one can conclude that the temperatures observed in this study undoubtably played a role in the high bacterial counts seen. The cold chain was not maintained as it should have been. It must also be remembered that this study was done in the winter months, and that had it been done in the warmer summer months, even higher temperatures may have been expected.

Aschaffenburg and Mullen Phosphatase Test

Milk contains at least 20 enzymes, and one of these, alkaline phosphatase, has a thermal resistance greater than that of the most heat-resistant of the non-spore-forming pathogens commonly found in milk (Holsinger *et al.* 1997). This property provided the basis for a negative test for alkaline phosphatase to indicate proper pasteurisation of milk. The alkaline phosphatase test is a rapid test which has been used to determine the efficiency of pasteurisation. The determination of the adequacy of pasteurisation is vital to ensure the safety of pasteurised milk, since individual tests for the detection of pathogens in pasteurised milk require time consuming procedures.

Raw milk with low aerobic plate counts or low somatic cell counts may or may not contain pathogenic bacteria capable of causing illness. Conversely, an elevated total bacterial count may or may not coexist with the presence of human pathogens. Pasteurisation is designed to

destroy all bacterial pathogens common to raw milk, excluding spore-forming bacteria (Steel *et al.* 1997).

The Foodstuffs, Cosmetics and Disinfectants Act provides for two methods for the pasteurisation of milk. The first method is the batch method whereby milk is heated to a temperature of at least 63°C and kept at that temperature for at least 30 minutes, after which it must be cooled within 30 minutes to a temperature lower than 5°C. The second method is the "high-temperature short-time (HTST) method" whereby milk is heated to 72°C for 15 seconds, after which it is rapidly cooled to a temperature of 5°C or less.

Of the 135 milk-shop milk samples tested, 52 (38.5%) were alkaline phosphatase positive indicating inadequate pasteurisation. In a national survey done in 1995 (Department of Health 1995), 14% of all "pasteurised" milk samples failed the phosphatase test. This result was lower than that of this research project, but nonetheless shows that significant percentages of "pasteurised" milk enter the market without being able to pass the alkaline phosphatase test. The alkaline phosphatase positive samples in this study all originated from Milk-shop 1 and Milk-shop 4, who were in effect repeatedly selling incorrectly pasteurised, or raw milk, to the public. Milk-shop 1 never obtained a negative alkaline phosphatase result. This could pose a serious health hazard to the consumer as correct pasteurisation is necessary to kill all the pathogens in the milk. Of significance was the fact that there were "Pasteurised milk" signs at all the milk-shops which misled the consumer into thinking that the milk was safe. Both Milk-shops 1 and 4 even displayed signs outside their shops, advertising the sale of pasteurised milk.

Every milk-shop in the study had a visible HTST pasteuriser in the milk-shop. Whether or not the milk went through the pasteuriser is unknown. Milk-shops 1 and 4 either did not pasteurise at all or the pasteuriser did not work efficiently. Some of the smaller pasteurisers do not have a return valve on the pasteuriser so that milk which was not heated correctly is not diverted back into the pasteuriser. The Foodstuffs, Cosmetics and Disinfectants Act states that if pasteurisation is carried out according to the high-temperature short-time method, then the process should be mechanically controlled with regard to the temperature range of the

milk and the period for which the milk is kept at the prescribed temperature. The apparatus used must be calibrated monthly to ensure the correctness of the pasteurisation process. Thermographic recordings of pasteurisation temperatures must be made and kept for at least four weeks. Questions must be asked as to whether or not the local authority ever analysed the milk and if so, why they did not do anything about the results. Since the same milk-shop was tested over a six-week period, the fault in pasteurisation was an ongoing problem and not an isolated case. The owners themselves should also have been aware of the regulations and seen to it that thermographic recordings were done. These recordings would have pointed out that the temperatures of pasteurisation were never achieved. A suggestion might be that people who work with perishable foods such as milk or meat which could affect the health of the consumer, would need to undergo some type of compulsory training before being able to work in a specific field, and that this training would include a component on the regulations concerning that industry as well as some knowledge on the processes involved. Public health aspects should also be part of the training.

A positive alkaline phosphatase result may also indicate the possible addition of raw milk to pasteurised milk. During processing, care must be taken to minimise the risk of contamination of the pasteurised product or the cooling medium. In pasteurisation by the HTST procedure, the pressure on the pasteurised product during the pasteurisation process is greater than that on the unpasteurised product (Ledford 1998). Any leakage will therefore occur in the direction from the pasteurised product to the unpasteurised product or cooling medium, and it is therefore unlikely that unpasteurised milk contaminated the pasteurised product in the pasteuriser. The possibility of this occurring on a daily basis in Milk-shops 1 and 4 is not possible. Once milk has been pasteurised it must be stored in a clean bulk tank and no raw milk should be added to the pasteurised product. Again, the author feels that it is highly unlikely that raw milk would have inadvertently been added to the pasteurised product on a daily basis, unless the milk-shop owners had no idea about the importance of separation of the two products. The local authority should also have picked this up and acted upon this fact, especially since they do monitor milk on a weekly basis.

Reactivation of the phosphatase enzyme by high bacterial numbers in the milk may also lead to a positive alkaline phosphatase test result. In this study, alkaline phosphatase levels in Milk-shops 1 and 4 were always positive over the six-week period, regardless of whether or not the bacterial counts were high. In the authors' opinion it is doubtful that reactivation of the phosphatase enzyme by high bacterial numbers was the cause of a positive alkaline phosphatase test, especially since it occurred on a daily basis. Microbial and reactivated phosphatase tests were not performed in this study, but may have been helpful in determining whether or not the phosphatase present was as a result of postpasteurisation contamination with microorganisms, or due to the raw milk containing spores which survived and germinated to produce heat-stable phosphatases.

If unpasteurised or raw milk is sold it should be labelled as such either on the bottle or sachet, or in the case of a bulk tank, on the tank itself, in accordance with the Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972). By not informing the consumer that the milk was not correctly pasteurised, the consumer could unknowingly be placed at risk of picking up potential pathogens, especially if that consumer had specifically chosen the milk because it was stated that it was pasteurised.

The milk sold from Milk-shops 1 and 4 was not fit for human consumption on the basis of the phosphatase test. As pasteurisation was not carried out correctly, it could pose a health hazard for the consumer, especially in immunocompromised people, such as those with AIDS, young children and the elderly (Farber & Hughes 1995).

Bacterial Counts

At the beginning of the trial insufficient serial dilutions were made for assessment of some of the milk-shop samples which had very high bacterial counts (aerobic plate counts, psychrotrophic counts and coliform counts). The bacterial growth from these shops was such that colonies were too numerous to count and as a result of this, no figures could be entered on the data sheet. Therefore, there are some discrepancies in the total number of samples

evaluated. Initially, the statisticians recommended a trial period of four weeks, but because values were missing due to the high counts, the trial was extended by two weeks so that there would be at least 20 samples taken from every milk-shop and from each of the supermarkets. There would also be four samples taken on each day of the week (Monday to Friday) over the period.

Standard Plate Count

Standard plate counts or total aerobic colony counts are used to estimate viable bacterial populations in the milk and reflect the hygienic practices used in the production and handling of the milk (Houghtby *et al.* 1994). They give a crude indication of the shelf-life of the milk. High microbial levels in raw milk may be attributed to factors such as poor hygiene during milk handling either on the farm or in the shop. High counts in pasteurised milk could be due to initial high bacterial counts in raw milk, post-pasteurisation contamination of the milk or failure to maintain the cold chain after initial on-farm primary chilling. Pasteurised milk may not contain more than 50 000 CFU/mℓ of milk (Government Printer 1997 Foodstuffs, Cosmetics and Disinfectants Act).

Standard plate counts for milk-shop milk ranged from 1.0×10^2 to 2.7×10^7 CFU/mℓ, with a median value of 41 000 CFU/mℓ. Using the arithmetic mean was not a good reflection of central tendency with this data, as the data contained some extreme values of bacterial counts which skewed the mean to a very high number. Therefore the median was used as it is less affected by extreme values. This can clearly be seen when one compares the mean and median values of the standard plate count. The data shows an arithmetic mean of 909 132 CFU/mℓ whereas in actual fact 74% of samples had counts lower than 50 000 CFU/mℓ and were therefore within the limits laid down by law (Foodstuffs, Cosmetics and Disinfectants Act). The geometric means were also computed and showed good correlations with the medians, although they were slightly higher. It is disturbing to note that there was such a large percentage of high counts. Results of a national survey done in 1995 by the Department of Health (Department of Health 1995) showed that 48% of pasteurised milk samples did not

comply with the standard plate count. This is higher than the results obtained in this study, but shows that the results of this study are not an isolated occurrence.

High counts were found in both correctly pasteurised milk, and in milk which was not correctly pasteurised. Looking at the shops which did not pasteurise their milk correctly, it was found that 33.3% of Milk-shop 1's and 70.4% of Milk-shop 4 's milk showed counts higher than 50 000 CFU/mℓ. Milk-shop 3 and Milk-shop 5 which did pasteurise their milk correctly showed counts of over 50 000 CFU/mℓ in 51.9% and 70.4% of cases respectively. Statistically, there was no significant ($p > 0.05$) difference in the standard plate count between those milk-shops which pasteurised and those that did not, and this was probably because the standard plate counts varied so much in each of the shops and each shop contained both high and low counts. This can also be seen when looking at the median values of the milk-shops. Milk-shops 1 and 4 (both alkaline phosphatase positive) had median values of 15 600 and 303 500 CFU/mℓ respectively, whereas Milk-shops 2, 3 and 5 (alkaline phosphatase negative) had medians of 900, 52 000 and 103 000 CFU/mℓ (Table 6). It cannot, however, be concluded from the above statement that pasteurisation has no effect on the standard plate count as many other factors, such as the maintenance of the cold chain and post pasteurisation contamination, also play a very important role in the total bacterial count (see discussion on bacterial counts).

There was no significant ($p > 0.05$) difference with respect to the standard plate count between the milk of Milk-shop 2 and that of the national distributor. Milk-shop 2's milk always had counts of less than 43 000 CFU/mℓ with a mean and median count of 6 939 and 900 CFU/mℓ respectively. This shop also differed significantly ($p < 0.05$) from the other milk-shops, indicating that it is possible for a milk-shop to have low aerobic bacterial counts. However, when one looks at the presence of inhibitory substances in the milk, the milk of Milk-shop 2 contained some form of inhibitory substance in 92.6% of samples. These inhibitory substances may well have inhibited the growth of the aerobic bacteria in the milk. Statistically it was not possible to ascertain whether or not the inhibitory substances played a role in the aerobic standard plate count of Milk-shop 2. Combining the data of all the milk-shops, no significant ($p < 0.05$) difference in the aerobic standard plate count could be found between milk which contained inhibitory substances and that which did not.

Over the trial period of six weeks, milk purchased on a Monday had a significantly ($p < 0.05$) higher standard plate count than milk purchased on a Friday. This could be due to the fact that leftover milk from the previous week was sold on a Monday. Bacterial counts would have increased over the weekend, especially if the cold chain was not maintained correctly. If one looks at individual weeks this did not always happen on each Monday at each milk-shop, but the combined data showed this trend.

The standard plate counts of milk from Milk-shop 3 and from Supermarket 3 differed significantly ($p< 0.05$) from each other, even though they were being sold from the same shop. This shows that even though both were sold from the same shop, the origin of the milk is important in determining its quality.

Standard plate counts for the national distributor's milk were always below 9 000 CFU/mℓ, indicating good quality milk from the farm to begin with as well as hygienic processing in the factory, and maintenance of the cold chain in distribution to the point of sale.

Psychrotrophic Bacterial Count

In developed countries, there is general agreement that the psychrotrophic bacterial count is the most reliable method of indicating conditions of production on the farm (Bishop & Juan 1988). As a result of the refrigeration of milk, psychrotrophic bacteria dominate over the mesophiles, and many argue that the standard plate count therefore cannot reflect the true conditions of production practices on the farm. In fact, spoilage of milk is accomplished by smaller numbers of psychrotrophic bacteria than by mesophilic bacteria. This is the reason why the standard plate count (mesophilic count) of milk will not give a reliable indication of the possible keeping quality of refrigerated milk (Bester *et al.* 1986). In Europe and the United States of America therefore, all milk is also subjected to the psychrotrophic bacterial count, which may not be greater than 100 000 CFU/mℓ (cited by Phillips & Griffiths 1990, Suhren & Heeschen 1990).

Psychrotrophic bacteria are ubiquitous in nature and are common contaminants of milk. They originate from equipment, milk stone deposits, air, water, and the people working with the milk (via the air) and give an indication of the potential shelf-life of the milk as they are able to grow under refrigerated conditions. Psychrotrophs are not part of the normal udder microflora, so the number present in raw milk is related to sanitary conditions during production and to length and temperature of storage before pasteurisation (Frank *et al.* 1992). The growth of psychrotrophs in milk result in off flavours such as stale, bitter, putrid and rancid tastes (Bester *et al.* 1986, Shah 1994). Defects in the milk such as coagulation and thickening which result from heat resistant lipases and proteinases degrading the casein also occur (Bramley & McKinnon 1990, Frank *et al.* 1992). These defects occur as a result of the extracellular enzymes produced by the psychrotrophs which survive heat treatment. Although psychrotrophs may account for less than 10% of the initial raw milk flora, they grow rapidly and dominate the flora during refrigeration (Shah 1994).

Internationally, the standard psychrotrophic bacterial count requires incubation of the plate for 10 days at 7°C (Marshall & Peeler 1992). This length of time is commercially unacceptable to determine the psychrotrophic population of raw or pasteurised milk. It does not allow for corrective action to be taken should a problem arise. In order to increase the numbers of gram negative psychrotrophic bacteria in milk, preliminary incubation may be used (Byrne *et al.* 1989). Various elevated incubation temperatures, e.g. 18°C or 21°C, have been recommended to give a more rapid and accurate estimate of the psychrotrophic population. The modified Petrifilm method with a pre-incubation temperature of 21°C for 18 hours, and a plate incubation period of 48 hours, was chosen for this study since it gave results within 66 hours and was highly correlated with the psychrotrophic bacterial count done at 7°C for 10 days. This method provides an estimate of the growth potential of psychrotrophic bacteria that may be present in the sample (White 1998). This selective preliminary incubation, followed by a rapid plating technique, could become a rapid test for potential shelf-life evaluation.

The rate of multiplication of psychrotrophic bacteria in refrigerated raw milk is often increased by the presence of high initial numbers. The growth of psychrotrophs in farm bulk

tank milk is also stimulated when cooling to 4°C is slow or delayed. Cooling from 35°C to < 5°C should be achieved within 2 hours (Thomas *et al.* 1971). In South Africa the regulations allow for a 3 hour time period to cool the milk down to < 5°C (Health Act, No 63 of 1977: regulations relating to milking sheds and the transport of milk, as amended). Farm bulk tank milk produced under reasonably hygienic conditions can be safely held at 4°C or less for 2 to 3 days before processing, but storage at 7.2°C or higher encourages the multiplication of psychrotrophic bacteria and the development of slightly unclean or rancid flavours within 48 hours (Thomas *et al.* 1971).

Only the milk obtained from the national distributor fell within the parameters laid down for psychrotrophs in Europe on all occasions except one. On this occasion, the national distributor's milk which was purchased at Supermarket 3, had a psychrotrophic bacterial count of 480 000 CFU/mℓ which was above the European legal limit and would have been rejected there. The milk purchased on that day had a temperature of 7.5°C which could partially explain the high psychrotrophic count as the storage temperature of milk has a significant effect on the lag phase of psychrotrophic bacteria, and a decrease in temperature results in an increased lag phase (Bester *et al.* 1986). During the rest of the trial period the national distributor's psychrotrophic median count ranged from 8 000 to 13 600 CFU/mℓ.

The psychrotrophic counts in milk-shop milk were extremely high, and even though the standard plate counts of 74% of milk-shop samples were within the legal limit of less than 50 000 CFU/mℓ, none of them would have passed the psychrotrophic count. Lag phases of psychrotrophic bacteria are generally shorter than those of mesophilic bacteria (Bester *et al.* 1986), which might be a reason why the psychrotrophic counts are so much higher than the mesophylic counts.

The presence of psychrotrophic bacteria in pasteurised milk is a result of post-pasteurisation contamination since most of these organisms are unable to survive heat treatment (Shah 1994, Gruetzmacher & Bradley 1999). These results clearly show that production practices in the milk-shops were not desirable, and that perhaps we should look at whether or not we should also use psychrotrophic counts in South Africa to evaluate our milk in terms of the keeping

quality of the milk. The shorter the shelf-life of the milk, the quicker it will deteriorate, even if refrigerated. However, many milk-shops are situated in the poorer socio-economic areas, where consumers might not have adequate refrigeration facilities. Many people may end up discarding milk as a result of the short shelf-life it has, in effect increasing the price they pay for a litre of milk.

Unlike the aerobic plate count, there was no significant ($p > 0.05$) difference in the psychrotrophic bacterial count between the different days of the week. This may have been due to the fact that the counts were high throughout the trial period in each one of the milk-shops. The storage temperature undoubtably played a role here too since the storage temperatures of the milk were on average always above 5°C.

The results showed that there was a significant ($p < 0.05$) difference in psychrotrophic bacterial counts between milk containing inhibitory substances and milk not containing any, which suggests that antimicrobial residues had an impact on the psychrotrophic numbers. Had the milk not contained any residues, it is possible that the psychrotrophic counts may have been even higher.

The results also showed that there was a significant ($p < 0.05$) difference in psychrotrophic bacterial counts between milk which was pasteurised correctly (alkaline phosphatase negative) and milk which was not pasteurised correctly (alkaline phosphatase positive), with counts lower in correctly pasteurised milk. Psychrotrophs are inactivated during pasteurisation and therefore the bacteria found in the pasteurised milk were as a result of post pasteurisation contamination indicating inadequate hygiene procedures in the shop. Failure to maintain the cold chain is another possible reason. The very high psychrotrophic counts in the unpasteurised milk suggest that contamination may have taken place both on the farm as well as in the shop and that high storage temperature may have also played a role.

There was a correlation between the aerobic plate counts and the psychrotrophic bacterial counts in Milk-shops 2 and 4, as well as in the national distributor's milk purchased from Supermarket 1 (Table 8). No correlation could be found in any of the remaining shops. Other

researchers who have looked for a correlation have found that the aerobic standard plate count cannot be used to predict the psychrotrophic count and is therefore also not a very good indicator of the shelf-life of the milk (Bester *et al.* 1986).

Coliform Counts

The presence of large numbers of coliform bacteria in milk are suggestive of unsanitary conditions or practices during production, processing, distribution or storage. Coliforms are destroyed by pasteurisation, and therefore their presence after correct pasteurisation is indicative of bacterial recontamination post-pasteurisation (White 1998).

Coliform counts in milk-shop milk varied tremendously between milk-shops over the six-week period ranging from 0 to 3.4 x 10^5 coliforms per mℓ. Even though 68% of samples had counts lower than 20 coliforms per mℓ, which is the maximum number allowed when the Petrifilm method of counting is used, the median value for milk-shop milk was 30 coliforms per mℓ and the geometric mean was 93 coliforms per mℓ. Both are unacceptably high and show that contamination took place post-pasteurisation. However, if one excludes the two milk-shops which sold raw milk, the median coliform count in the remaining milk-shops was below the 20 coliforms per mℓ limit allowed for in the Foodstuffs, Cosmetics and Disinfectants Act (Table 9). Nevertheless, milk-shop owners need to be made more aware of basic hygiene measures when handling the milk. Coliform counts for the national distributor's milk were always zero, again indicating hygienic processing of the milk.

It is possible for milk-shops to keep post-pasteurisation contamination to a minimum, as Milk-shop 3 did not differ from the national distributor's milk. In the national survey carried out in 1995 by the Department of Health (Department of Health 1995), 48% of pasteurised milk samples contained coliforms at levels above the legal limit. This was higher than the result obtained in this study, re-emphasising the fact that the results obtained in this study are plausible. It therefore shows that the standard of pasteurised milk sold in this country is, on the whole, not up to the standards laid down in the Foodstuffs, Cosmetics and Disinfectants

Act, and is in fact being sold illegally. Nevertheless, it must also be remembered that the figures obtained by the Department of Health included milk from both large and small distributors and does not necessarily mean that the results are a reflection of both. In this study, the national distributor's milk never contained any coliforms and therefore always conformed with the standards prescribed in South Africa.

As with the standard plate count, there was a significant ($p < 0.05$) increase in coliforms in Monday milk samples compared with Wednesday and Friday samples. This once again suggests that milk not sold was stored over the weekend, and used for sale on Monday. Post-pasteurisation contamination with coliforms must have taken place, and with holding temperatures above 5 °C, these coliforms multiplied over the weekend, giving high counts on Mondays.

It is difficult to produce milk on the farm without any coliforms being present since coliforms are ubiquitous in the environment. Pasteurisation is therefore a processing step that ensures the destruction of coliforms acquired on the farm. Milk-shops 1 and 4 differed significantly ($p < 0.05$) from the other shops with respect to the coliform count, in that they were much higher. They were also the only two shops which did not pasteurise correctly, and the results clearly showed that there was a significant ($p < 0.05$) difference in coliform count between those shops which pasteurised and those which did not, indicating that pasteurisation is an important measure in decreasing coliform counts.

Antibiotics or other inhibitory substances in the milk suppressed coliform bacteria in the milk since there was a significant ($p < 0.05$) difference in coliform count between milk samples containing inhibitory substances and those which did not.

Bacterial Counts in General

Standard plate counts, coliform counts and psychrotrophic counts in milk-shop milk were often above legal limits. It is not known how long milk was stored in the display cabinets or

bulk tank prior to purchase, although results showed that milk on a Monday often had higher bacterial counts than milk purchased later in the week. This suggests that milk, which was often contaminated by spoilage organisms, was not discarded but kept until it was sold. Milk no longer fresh should have been discarded by shop owners and not kept on the shelf until it was ultimately purchased. Sampling took place every second day except for the time period over a weekend when it took place four days later due to the design of the study. As bacterial counts were highest on a Monday, it shows that the milk-shops purchased milk at least once a week, if not more. Milk-shops buy milk direct from the farm and can process immediately, unlike the bigger distributors who lose an average of four days from the time it is pumped into the tanker on the farm, until it is finally purchased by the public in a retail store. Hygienically produced milk ought to have a shelf-life of at least 10 days. Bishop (1993) showed that the estimated shelf-life of milk with a total bacterial count of < 1 000 CFU/mℓ was > 14 days. Milk with a total bacterial count of between 1 000 and 200 000 CFU/mℓ had an estimated shelf-life of 10 to 14 days. Milk with a total bacterial count of > 200 000 CFU/mℓ had an estimated shelf-life of < 10 days. These estimates show that the shelf-life of milk-shop milk was most probably 7 days or less, which is very short.

Inadequately washed and sterilized milking and milk handling equipment constitute the main source of bacteria in farm milk supplies (Thomas *et al.* 1971). It has been reported that good procedures of cleaning and sterilizing milking equipment resulted in milk with lower numbers of total and of psychrotrophic bacteria than in milk produced on farms with poor procedures (cited by Thomas *et al.* 1971). Milkstone deposits are caused by inadequate milking machine cleaning and/or poor quality (hard) water in the dairy. Milkstone is a combination of mineral and protein deposits on stainless steel and other surfaces. It can protect bacteria from hot water, detergents and the sanitisers used to clean the milking machine. It provides nutrients for the rapid growth of bacteria in the milk. When the milkstone deposits break down or are dislodged from the stainless steel surface, large numbers of bacteria can be released into the milk.

The temperature of the cleaning agent is also of utmost importance. Only 1% of the rinses of pipeline plants had unsatisfactory colony counts when the initial temperature of the detergent

wash solution circulated was >77°C, whereas nearly 40% had unsatisfactory counts and 30% of the rinses contained coli-aerogenes organisms when the initial circulation temperature was < 65°C (Thomas *et al.* 1971). It was further found that poorly cleansed pipeline milking plants contributed to exceedingly large numbers of bacteria in the milk, especially in the presence of milkstone or milky residues. The correct concentrations of the detergent used is essential, as is the time the detergent is in contact with the equipment (contact time) and the circulation temperature.

Thomas *et al.* (1971) also found that the bacterial content (including the psychrotrophs) of milk was much higher in summer than in winter, particularly when production practices were poor. This study was done in the winter months from June to August, and counts were therefore expected to be even higher in the summer months when daily temperatures are much higher than in winter.

High bacterial counts could also be due to farmers not chilling the milk fast enough on the farm or not adequately maintaining the cold chain after primary chilling, such as when the milk is transported or after bottling in the shop. At sale, Milk-shop 1 had temperatures varying from 3.5°C to 10°C with 48% of samples less than 5°C. Milk-shop 4's temperatures varied from 6.5°C to 11°C with none of the milk ever being below 5°C. Temperature abuse will influence bacterial counts.

Another reason for high bacterial counts could be poor quality water on the farm. Water in the dairy should be potable as not only can poor quality water have an effect on bacterial counts, but hard water has a negative effect on cleaning agents, binding to them so that higher concentrations have to be used in the cleaning of equipment (Clark 1962). If the water in the dairy is contaminated with bacteria it must be chlorinated (2 - 3 ppm)(Giesecke *et al.* 1994). The water used in the milk-shop for cleaning out the storage tanks and pasteuriser must also be potable. As all the milk-shops were situated in developed urban areas, it is most likely that the water used in these milk-shops was chlorinated municipal water, and therefore the water should have been potable.

Farmers who sell milk to milk-shops are usually small-scale farmers who cannot afford to distribute their own milk. They often also buy in milk from other small farmers to make up volumes. This can have detrimental effects on milk quality as the more milk is handled and the cold chain is broken, the higher bacterial counts become.

Supervision in the parlour and milk-room is often lacking on South African dairy farms. The milkers are usually left on their own. Workers are also not trained appropriately on the correct milking procedure or in the hygienic handling of milk once it leaves the cow. They are often ignorant of basic hygiene measures.

Transport of milk to the milk-shop is another area where bacterial counts can be increased. Milk is often transported in small bulk tanks on the back of trailers or bakkies. These are not refrigerated and therefore the cold chain is broken, especially when the weather is hot. Some milk-shop owners have to travel to various farms to pick up milk supplies to make up a large enough volume. Pipes used to pump the milk from the bulk tank on the farm into the tank on the vehicle are often not cleaned in between farms and the milk remaining in these pipes during transport to the next farm become an ideal medium for bacteria to multiply in at ambient temperatures.

In the milk-shop, the effectiveness of cleaning and sanitising practices greatly influences the level of contamination, and the pasteuriser can be a source of contamination if it is inadequately cleaned or maintained (Ledford 1998, Gruetzmacher & Bradley 1999). Micro-organisms may originate from pipes and valves. Air and condensates may also be significant sources of contamination, as can be the bulk tank where milk is stored after pasteurisation. It was shown that aseptically sampled milk from the outlet of a clean pasteuriser could achieve a shelf-life of more than 30 days (Gruetzmacher & Bradley 1999).

Training programmes for staff working in milk-shops is essential as these people work with food, and are often ignorant of basic hygiene principles. Milk-shop owners (and dairy farmers) should employ hygiene programmes on the farm and in the shop which should

consist of good manufacturing processes, quality control, hazard analysis and critical control point principles.

Escherichia coli

E. coli is a faecal indicator organism, whose recovery from milk suggests that other organisms of faecal origin, including pathogens such as *Salmonella* and *Campylobacter*, may also be present. *E. coli* is readily isolated from the intestinal tract of warm blooded animals, including dairy cattle. Raw milk is contaminated through contact with faecal material. *E. coli* may also be isolated from the milk of mastitic animals. *E. coli* is destroyed by pasteurisation with a wide margin of safety (Holsinger *et al.* 1997, Ryser 1998).

Nearly 18% of milk-shop milk samples were *E. coli* positive, 95% of which originated from the two milk-shops which sold inadequately pasteurised milk. Unfortunately, on many of the plates containing 1 mℓ of undiluted milk from Milk-shop 4, it was impossible to accurately say whether or not *E. coli* was present since the plate contained so many coliforms that all one could see was one enormous gas bubble under the film. These were labelled as suspect samples. This would have to be a drawback of using the dry rehydrated film method for the coliform and *E. coli* count, since high coliform numbers obliterate *E. coli* organisms. Other methods such as the Modified Eijkman Test for *E. coli* might be more useful in such cases, but this method is far more labourious to perform and takes far more time to get results. If one were to add in the suspect samples from Milk-shop 4 then nearly 26% of all milk-shop samples purchased were positive for *E. coli*. In fact then, 78% of Milk-shop 1's milk and 41% of Milk-shop 4's milk contained *E. coli*, indicating gross contamination of the milk at farm level. This high prevalence is possible since the milk from these two milk-shops was not pasteurised correctly, and was therefore raw. Such milk is very easily contaminated with *E. coli* since the organism is prevalent in the environment. These results again correspond well with the results obtained by the Department of Health in 1995 (Department of Health 1995), where it was found that 26% of all pasteurised milk samples contained *E. coli*.

As *E. coli* is destroyed by pasteurisation, the presence of this organism in pasteurised milk samples would indicate human contamination after pasteurisation by handlers who practice poor personal hygiene or by contact with water containing human sewage. People handling milk should be educated in safe food handling techniques and proper personal hygiene practices including hand washing after using the lavatory.

The national distributor's milk was always negative for *E. coli* organisms indicating effective pasteurisation of raw milk and no recontamination afterwards.

An attempt was made to determine the presence of heat-stable *E. coli* enterotoxins in the milk using the *E. coli* ST EIA test kit (Oxoid), which is a competitive enzyme immunoassay used to detect *E. coli* enterotoxins. Centrifuged milk samples were used as it was not possible to isolate *E. coli* organisms from the petrifilm so as to culture them. The method however, clearly stipulates that a culture filtrate must be used. The results, after using the whole milk, had to be dismissed as most of them showed a (false) positive result. Future research might look at the presence of these toxins in South African milk supplies.

Staphylococcus aureus and *S. aureus* Enterotoxins

Staphylococcus aureus is ubiquitous within the farm environment and carried by approximately half of the human population, and therefore many dairy products contain low levels of enterotoxigenic staphylococci (Ryser 1998). Forty percent of all milk-shop milk contained the organism *S. aureus*. Organisms in this study were found in incorrectly pasteurised milk, which indicates that they may have originated from animals with subclinical mastitis. *S. aureus* is the dominant mastitis organism in South Africa, being prevalent in at least 75% of South African herds (Giesecke *et al.* 1994, Swartz *et al.* 1984). *S. aureus* in raw milk may also have originated from human carriers.

The organism was also isolated from milk which had been correctly pasteurised, indicating that it must have originated from the people who handle the milk, since this organism is

destroyed by pasteurisation (Asperger 1994). Surveys have shown that up to 60% of humans are nasal carriers of this organism, and that between 5% and 20% of people carry the organism as part of their normal skin flora (Asperger 1994).

S. aureus is a poor competitor and is readily outgrown by lactic acid-producing micro-organisms, so growth is limited in raw milk (Holsinger *et al.* 1997, Asperger 1994). Notwithstanding this fact, 96.3% of milk from Milk-shop 1 and 29.6 % of milk from Milk-shop 4 contained the organism. If the milk is not refrigerated, the enterotoxigenic strains can grow and produce enterotoxin. Of the 51 *S. aureus* cultures which were tested, four (7.83%) produced heat stable staphylococcal enterotoxins A (SEA), B (SEB), D (SED) or a combination of them. All toxin producing strains isolated originated from Milk-shop 1. Four out of 19 (21%) *S. aureus* strains from this particular milk-shop produced toxins, and were thus enterotoxigenic.

S. aureus enterotoxins can survive the pasteurisation process and may cause food poisoning in man, thereby posing a health risk (Flowers *et al.* 1992). When ingested they cause nausea, vomiting and diarrhoea. Even if this milk had subsequently been pasteurised correctly, the toxin remains a health risk since it is heat stable. The occurrence of the enterotoxigenic strains in milk calls for improved udder health, milking hygiene and milk handling.

SEA/SEB and SEA/SEB/SED were the most frequently produced enterotoxins. Bolstridge & Roth (1985) reported that 18.9% of *S. aureus* isolates from both raw and processed dairy products purchased in South Africa were found to be enterotoxigenic, with the majority producing enterotoxins A or C or a combination of A and C. A study done in Kenya by Ombui *et al.* (1992) found enterotoxin C to be the most frequently encountered toxin in that country. Most food poisoning outbreaks involve enterotoxins A and D as they are produced under a much wider range of environmental conditions than B and C (Asperger 1994).

The production of enterotoxin by staphylococci can be completely managed by temperature control. Toxin production is favoured if the milk is cooled slowly after milking, if it is inadequately stored, and if storage before use is too long. Multiplication of the bacteria and

toxin formation are almost completely inhibited below 7°C (Asperger 1994). In this temperature range only psychrotrophic spoilage bacteria will grow which have a distinct effect on staphylococci. Temperature abuse above 10°C and poor starter culture activity during fermentation are the most often cited contributing factors in dairy-related outbreaks of staphylococcal poisoning (Ryser 1998).

The national distributor's milk did not contain any *S. aureus*, or toxins in the 15 samples tested.

Thermo-resistant Inhibitory Substances

Of public health importance was the fact that 54% of milk-shop milk samples purchased contained some type of inhibitory substance. These could consist of antibiotics or other antimicrobials such as formalin or hydrogen peroxide which may have been (illegally) added to the milk to increase the shelf-life.

Antibiotics are administered to control diseases such as mastitis in lactating animals, and antibiotics applied either by infusion, injection or orally, may enter the milk supply. The main source of antibiotic contamination in the milk is through the application of intramammary products. Untreated quarters may be contaminated via the blood circulation or by diffusion. Other ways of contamination are the percutaneous, intrauterine, subcutaneous, intramuscular and intravenous application of antibiotics.

Antibiotics can enter the milk supply:

i) if the correct withholding period is not adhered to by the farmer after administering antibiotics to lactating cows

ii) through extra-label use of antibiotics (ie. increased dose, increased frequency of treatment, unproven route of administration) which is shown to be associated with an increased risk that antibiotic levels in milk will persist beyond the milk-withholding time period (Angelidis *et al.* 1999)

iii) through accidental or intentional transfer of a batch of milk that is contaminated with antibiotics in the bulk tank.

Milking equipment which is not rinsed adequately may also contain residues of disinfectants which are used in the cleaning process.

The prevalence of inhibitory substances in milk-shop milk was high, ranging from 33.3% in Milk-shop 5 to 92.6% in Milk-shop 2. Residues are illegal in terms of the Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972). The fact that there are antibiotics in the milk may mean that the milk originated from cows which were treated for mastitis, and therefore the milk may also contain large numbers of potentially dangerous pathogens such as *S. aureus* which could pose another threat to public health. There may also be biologically active metabolites or unchanged drugs in the milk which may result in problems such as allergies in man or may lead to increased resistance of micro-organisms (Bishop *et al.* 1994). Bacterial resistance can affect therapy by reducing the ability of an antibiotic to eliminate or control infection. Conditions favouring the development and selection of bacteria carrying resistance factors are thought to be associated with repeated or prolonged use (Sundlof & Cooper 1996). In the worst case, infection can overcome the victim before appropriate therapy can be instituted. In some cases, resistance renders an infection immune to virtually every antibiotic available. More often bacterial resistance increases therapeutic costs because inappropriate drug choices prolong diseases.

Nearly all reports of adverse reactions from food-borne residues implicate penicillin as the offending agent, and the source of penicillin residues is most often milk or dairy products (Sundlof & Cooper 1996). These milk residues most likely originated from intramammary infusion of penicillin used in the treatment of mastitis. Although a substantial number of farm milk samples have been found to contain small amounts of penicillin, there have been relatively few published reports of adverse reactions from milk residues (Sundlof & Cooper 1996). Symptoms varied in intensity from mild skin rashes to exfoliative dermatitis (Sundlof & Cooper 1996). Both epidemiologic and experimental data indicate that food-borne residues

of penicillin as low as 5 to 10 international units (IU) are capable of producing allergic reactions in previously sensitized persons (Sundlof & Cooper 1996).

It cannot be excluded that antibiotics, e.g. chloramphenicol, may have a direct toxic effect on the consumer. In addition to acute incidents related to residues, there is also concern about the long term effects on public health from chronic exposure to illegal residues. Milk is an important part of the diet of infants and young children and unfortunately, on a body weight basis, they consume greater quantities of milk than adults. Residues, such as those found in the milk-shop milk, are therefore of even greater concern in this segment of the population.

Intramammary infusions are readily available to dairy farmers who can buy many of them over the counter. There is also no monitoring programme in South Africa to ensure that farmers adhere to the correct withdrawal period. Previously it was stated that 40% of all milk-shop milk contained the organism *S. aureus*, a major cause of mastitis. This may very well be the reason why the farmers are treating their animals with antibiotics. These findings may reflect misuse or abuse of antibiotics by farmers.

Inhibitory substances may have influenced the test results of psychrotrophic and coliform bacterial counts, giving lower values due to inhibition of bacterial growth, as there was a significant difference in these counts between milk containing inhibitory substances, and milk not containing any. Suhren (1995) demonstrated that the activity of bacteria when the total bacterial count exceeded about log 6.5/mℓ (3 million/mℓ) could result in false negatives. She concluded that this was probably due to the ß-lactamase producing micro-organisms within the flora. Only five samples, all originating from Milk-shop 4, had counts in excess of 3 million CFU/mℓ on the standard plate count. They were all, however, positive for inhibitory substances.

The brilliant black reduction test is a screening test and does not specify what inhibitory substance was used. Positive samples would need to be further analysed by more sophisticated methods which allow for the identification and quantification of the antimicrobial substance used. Penicillinase may be added to the positive milk sample and

reincubated to see whether or not the substance present was a beta lactam antibiotic (penicillins, cephalosporins) or not.

The major non-specific antibacterial factors in milk, namely lactoferrin and lysozyme, whose content is increased in colostrum and mastitic milk, have been given as reasons for "false" positives in microbial inhibitor tests. Studies have shown that the concentration of single components needed to achieve an inhibition was unphysiologically high, whereas the combination of both substances showed a synergistic effect and therefore showed positive results in physiological concentrations (Suhren 1995, Suhren & Heeschen 1996).

False positive assay outcomes are most common on individual animal samples, but less so in bulk tank samples, and are rarely found in tanker milk or milk obtained from more than one supplier (Cullor 1996). Milk-shop milk usually originates from more than one supplier (personal communication with shop owners).

Bacillus stearothermophilus is insensitive towards practically applied sanitisers and is not markedly influenced by concentrations to be expected in milk samples (Suhren 1995, Suhren & Heeschen 1996).

Somatic Cell Count

High somatic cell counts are found in cows in very early or very late lactation, as well as in cows with udder infections, and consist mainly of white blood cells (pus cells) and some epithelial cells. Somatic cells affect the soundness of milk and high counts make the milk aesthetically unacceptable. Eighty-one percent of milk-shop milk samples had somatic cell counts below the legal limit of 500 000 cells/mℓ. From an udder health point of view, a count of 500 000 cells/mℓ is high and indicates that a large percentage of the dairy herd has subclinical mastitis. Only bulk tank (herd) counts of less than 200 000 cells/mℓ suggest that mastitis is under control. Even though the somatic cell counts were below legal limits, in 83% of the milk-shop samples they were above 200 000 cells/mℓ and therefore high from an udder

health point of view. This is substantiated by the high prevalence of *S. aureus* in milk-shop milk. *S. aureus* was present in 96% and 41% of Milk-shops 1 and 5 respectively, and both these shops had mean somatic cell counts above 400 000 cells/mℓ.

The national distributor's milk always had counts of less than 150 000 cells/mℓ. Somatic cell counts are decreased in the clarifying process which is done at larger dairies and processing plants, and this may be the reason why the somatic cell count of the national distributor was so constant and so low over the six-week period.

Brucella abortus

Brucella abortus is a zoonosis which causes undulant fever in man and has not yet been eradicated from cattle in South Africa. Milk-borne brucellosis continues to be a problem worldwide although vaccinations and milk pasteurisation have drastically decreased the incidence of brucellosis transmitted via milk (Flowers *et al.* 1992). Once infected with brucellosis, cattle shed the organisms intermittently in the milk for as long as five months, thereby infecting those who drink the milk (Ryser 1998). When naturally contaminated raw milk is held at 25°C to 37°C, *Brucella* populations typically decrease to non-detectable levels within 2 to 3 days. However, brucellae survive at least 42 and 800 days if such milk is stored at plus 4°C and minus 40°C respectively (Ryser 1998). Commercial pasteurisation effectively kills *B. abortus* with a large margin of safety (Garin-Bastuji & Verger 1994, Ryser 1998).

There is no single test by which a bacterium can be identified as *Brucella* (Garin-Bastuji & Verger 1994). A combination of growth characteristics, serological and bacteriological methods is usually needed for identification. *Brucella* are usually present in low numbers in bulk tank samples and isolation from such milk specimens is very unlikely (Garin-Bastuji & Verger 1994). As a result of this, the diagnosis of *Brucella* infection is easier if based on serological methods. The brucella milk ring test (BMRT), which detects anti-*Brucella* antibodies in the milk, is routinely used as a screening test for the detection of brucellosis.

All samples in this trial tested by means of the brucella milk ring test were negative for antibodies to the organism. In the field the sensitivity is increased when the test is repeated each month. It is therefore unlikely that there could have been false negatives as all milk samples were tested at least 2 to 3 times per week. Due to the fact that the brucella milk ring test is highly sensitive, it is far more likely to get false positive results and these have to be interpreted with care. In a national survey done in South Africa in 1995, a total of 11 out of 918 (1.2%) samples tested were found to be positive for the presence of *Brucella* antibodies (Department of Health 1995). The prevalence of the disease is low in South Africa, although unconfirmed reports have indicated that the incidence of the disease is on the increase due to the fact that the Brucella Eradication Scheme is no longer administered by the Government, and therefore no compensation is paid out to positive herds which are slaughtered.

Salmonella

Salmonella spp. are food-borne zoonotic pathogens which can contaminate milk and other foods as a result of poor hygiene practices. Salmonellae are widespread in the environment and can therefore enter the milk from various sources including insects, birds, rodents, pets, cattle, water and humans (El-Gazzar & Marth 1992). Salmonellae normally grow at 35°C to 37°C, but can grow at much lower temperatures, provided that the incubation time is suitably extended (El-Gazzar & Marth 1992). Standard vat and high-temperature, short-time pasteurisation destroy salmonellae with a wide margin of safety (Marth 1969, Ryser 1998, Holsinger *et al.* 1997). *Salmonella* decreases in milk during extended storage at less than or equal to 7°C, and to minimize problems, milk or any other foods should be held at or below 2°C to 5°C at all times (El-Gazzar & Marth 1992).

The gastrointestinal illness which develops from the ingestion of *Salmonella* spp. can be treated successfully with antibiotics, but there is a segment of the population (immunocompromised people) who will develop serious complications and may even die, if infected (Mossel 1987, Holsinger *et al.* 1997).

All *E. coli* positive samples tested for the presence of *Salmonella* were negative for the latter group of organisms. Nevertheless, this does not preclude the fact that other faecal organisms such as *Campylobacter* or *Yersinia* may well be present in such samples. The low incidence of this pathogen in raw milk samples could possibly have been due to the high aerobic plate counts found in the incorrectly pasteurised milk. As with pathogens such as *S. aureus*, lactic acid producing bacteria may compete with *Salmonella* and limit their growth.

If salmonellae had been present in milk-shop milk, numbers could have increased as temperatures were often above 5°C. At 12°C and 20°C, *Salmonella* populations double every 8.8 and 20 hours respectively, which reinforces the need for constant refrigeration (Ryser 1998).

The organism *Campylobacter* was not looked for in *E. coli* positive samples as the survival of many strains of *C. jejuni* in raw milk is poor (Flowers *et al.* 1992). In general, *C. jejuni* grows poorly in food and dies rapidly when exposed to ambient temperature and atmospheres. This could explain why low incidences, and difficulty in recovery of the organism from suspect milk samples, have been reported (Flowers *et al.* 1992). However, only low numbers of *C. jejuni* (2 to 3 cells per millilitre) are needed to produce symptoms of gastroenteritis in humans (Robinson & Jones 1981). Further research might be needed in this area, perhaps looking at the incidence of *C. jejuni* in bovine faecal material where it might be isolated more easily.

pH

The average pH of normal cow's milk is considered to be 6.6. The mean pH value at sale for the milk-shop milk and for the national distributor's milk was 6.76, and they did not differ from each other. The mean pH value after incubating the milk at 21°C for 18 hours for milk-shop milk samples was 6.62 and for the national distributor's milk was 6.77, and this was a significant ($p < 0.05$) difference. The milk-shop milk was also visibly thicker than the national

distributor's milk after incubation. At this stage, the national distributor's milk still showed a normal consistency.

By incubating the milk, significant numbers of bacteria were able to multiply and form lactic acid which resulted in a small decrease in pH. This corresponds to the fact that there was also a significant difference between milk-shops and the national distributor's milk in respect of the psychrotrophic count which was also done after incubating the milk at 21 °C for 18 hours.

Incubating the milk, to determine the consistency of the milk may give a crude indication of the psychrotrophic count of the milk, and may also possibly give an indirect indication of the shelf-life of the milk.

GENERAL CONCLUSIONS

The results showed that milk-shop milk differed significantly ($p < 0.05$) from the milk which originated from the national distributor, and that 87% of the milk samples purchased at milk-shops were not fit for human consumption on the basis of the Foodstuffs, Cosmetics and Disinfectants Act. They further showed that the milk purchased from milk-shop outlets is of a poor bacteriological quality and that many samples contained pathogens, residues of inhibitory substances and toxins which may affect the health of the consumer. Consumers are therefore unwittingly exposed to unnecessary health risks, by drinking unsafe milk. These findings are similar to those found after a survey done throughout South Africa in 1995 by the Department of Health which concluded that 73% of pasteurised milk samples did not comply with all the regulations (Department of Health 1995). Their results included the milk of national distributors. In this study it was found that all the samples purchased from the national distributor passed all the criteria laid down in the Act, and therefore samples which were obtained from national distributors in the national study may have improved the results to some extent.

The fact that nearly 40% of milk samples were incorrectly pasteurised, and the high prevalence of *E. coli* and *S. aureus* in these raw milk samples proves the greater risk of raw milk. People might mistakenly believe that if they have been drinking raw milk for a long time, they will not become ill from it. However, if there are new pathogenic organisms in the milk to which the consumers have not been exposed, or normally occurring bacteria are present in very high numbers, then illness can occur. However simple exposure to pathogens does not necessarily lead to human infection or disease. The health impact of exposure is influenced by the volume of milk consumed, the concentration of the pathogens within that milk, the total number of organisms to which a person is exposed through various sources and the dose-response of an individual to such exposure (Steele *et al.* 1997). These factors will vary between situations and individuals. High risk people who may be particularly susceptible to infection include immunocompromised people whose immune systems are deficient either because of an immunodeficiency disorder or because of treatment with immunosuppressive drugs. These would include pregnant women, alcoholics, diabetics, transplant recipients, AIDS and cancer patients, very young infants, steroid users, and patients with chronic renal disease and iron storage disorders (Farber & Hughes 1995).

Not only can unsafe milk affect the health of the consumer, but it may also have economic implications such as medical and hospitalization costs, mortality costs, productivity losses, and the long-term reduction in quality of life. This could place a burden on primary health care services, the employers and employees due to absenteeism.

To produce safe, sound and wholesome milk for the consumer entails good production practices throughout the chain from the cow to the consumer. This includes the milking of healthy animals, the use of clean and hygienic equipment on the farm and during processing, maintenance of the cold chain throughout the production chain, effective pasteurisation and prevention of post-pasteurisation contamination. People handling milk should be educated in safe food handling techniques and proper personal hygiene practices.

There is a need for more stringent control over milk-shops by the relevant authorities. However, public education is also needed as legislation alone is insufficient.

The results of this study have shown that we can reject the null hypothesis and accept the alternative hypothesis which stated that there was a statistically significant difference in quality at point of sale between milk sold from "milk-shops" and milk which originated from a commercial national distributor.