DETERMINATION OF MILK-BORNE PUBLIC HEALTH HAZARDS IN RAW MILK FROM RETAIL OUTLETS AROUND MANZINI CITY

B. L. Nkambule[1] and A. M. Dlamini[2*]
adlamini@uniswa.sz
[1]Integrated Programmes Department, World Vision Swaziland, Mbabane, Swaziland
[2] Department of Animal Science, University of Swaziland, P.O. Luyengo, Swaziland

ABSTRACT

Following milk price deregulation in the late 1990's, the number of dairy farmers selling raw milk direct to consumers increased remarkably. The public health safety of such milk has not been ascertained. This study was carried out to determine milk-borne public health hazards in raw milk sold by retail outlets around Manzini. Milk samples were obtained from seven raw milk retail outlets around the Manzini- Malkerns corridor. Total bacterial counts, psychrotrophic bacterial counts, coliform counts, Escherichia coli counts, yeast and moulds counts were determined. Milk samples were also tested for milk freshness, composition, adulteration and presence of antimicrobial substances. The overall results obtained revealed that raw milk was of poor hygienic quality and could be a health hazard to the public. Milk samples from all the retail outlets did not meet the international standards for acceptable hygienic quality. Total bacterial counts reached up to (5.2 x 10^7 cfu/mL), psychrotrophic bacterial counts reached (1.1 x 10^7 cfu/mL), coliform counts were (2 x 10^9 cfu/mL), E. coli counts reached (3.8 x10^5 cfu/mL) and yeast and moulds counts were (2.7 x 10^6 cfu/mL). All the raw milk samples had lactic acid above the standard, <0.22 %(v/v) for fresh milk. Storage temperatures from all the milk samples were above the maximum standard temperature (10^oC). About 82% of the milk samples tested positive to unacceptable antimicrobial residues sensitivity levels. There was also a big variation in butter fat percentage among samples taken during the study period. Milk from Retailer 2 had specific gravity lower than the minimum level, 1.025g/cm^3. This corresponded to at least 5% (v/v) water addition. These results have suggested that poor milk hygienic quality may be attributed to poor cleaning and sanitising of milking and storage equipment, poor storage temperatures, long storage hours of raw milk at the farm, poor routine hygienic practices and ill health of both the milking cows and personnel handling the milk. Variations in butter fat percentages can be attributed to poor agitation in milk shop cooler tanks as most of them had no stirring facilities. Promotion of measures concerning elementary hygiene at farm level and at the market level is highly recommended. Of major importance, efforts must be made to strengthen the country's quality control system in order to develop a competitive and a sustainable dairy industry.

Key words: raw milk, coliforms, hygienic quality, antimicrobial residues, bacterial counts

INTRODUCTION

Milk has been described as one of the most important and most valuable, but dangerous man's food (van den Berg, 1988; Batt, 1996). It consists of 87% water and essential substances to man such as proteins of high biological value, carbohydrates, fats, all B-vitamins, vitamin A, calcium and phosphorus. Mathewman (1993) referred to milk as a complement for all diets, therefore a valuable source of nutrient for growing children, convalescing adults, pregnant and lactating women and for sick people as it sustains and nourishes the body. It is used in many recipes and

made into milk products such as cheese, yoghurt, and ice-cream. In Southern Africa including Swaziland, milk is traditionally consumed raw or allowed to ferment naturally or sometimes pasteurised prior to consumption (FAO, 1990; Masarirambi *et al*., 2009).

On the other hand milk could also be dangerous because it may be contaminated with harmful or pathogenic bacteria which can cause serious diseases such as typhoid fever, diphtheria, septic sore throat, scarlet fever, dysentery, Q-fever, and other kinds of food-borne illness (Scott, 1998; Murinda *et al*., 2004). Food poisoning bacteria associated with milk include *Escherichia coli* 0157:H7, *Listeria monocytogenes*, *Salmonella typhimurium* DT-104, *Campylobacter jejuni*, and *Yersinia enterocolitica* (Cody *et al.,* 1999; Oliver *et al*., 2005). *Listeria monocytogenes* has been viewed as a potential hazard to both human and animal health as it can be transmitted from the farm through the food chain and ultimately to humans (Batt, 1996). Several cases of pathogenic *E. coli* 0157:H7 infections have been reported around the world (Jayarao and Henning, 2001). This pathogen can cause death or serious adverse life-long health conditions to young children, the elderly and sickly people because of their compromised immune systems. Cody *et al.* (1999) reported that *Salmonella typhimurium* DT-104, have shown alarming resistance to many commonly used antibiotics. Other serious pathogens that can be transmitted from infected animals to humans through the consumption of raw milk include *Brucella abortus* and *Mycobacterium bovis* (Gilmour and Rowe, 1990; Gall and Nielson, 2004). In addition, the high levels of chemicals in milk continue to be a global concern as they are usually detected above safety levels of concentration stipulated by the FDA (Andrew *et al.*, 1997). Inhibitory substances in milk are a result of antibiotic residues from treated diseased animals, disinfectants for maintaining hygiene in the dairy and pesticides in the feedstuff (Gilmour and Rowe, 1990). Antibiotics in milk are a concern because of three reasons. First allergic risks; second, development of drug resistant human pathogens and thirdly, inhibition of starter cultures (Bischoff *et al.,* 2003).

Milk production in Swaziland is mainly dominated by rural small holder producers. Reports have shown that over the past few decades, more than 70% of milk produced in Swaziland is sold directly from the farm to consumers as raw milk (FAO, 2003; SDB, 2010). The high proportion of informal raw milk sales is attributed to the price deregulation in the dairy industry which has led to higher sale prices in the informal markets when compared to prices offered by processors (SDB, 2010). This may pose a potential public health hazard because usually the milk is consumed unpasteurized by the buyers. It has been reported in other countries that distributors of raw milk a nd milk products in small towns and rural sections usually do not meet the minimum requirements for public health (Omore *et al.,* 1999; Anonymous, 2003; D'Amico and Donnelly, 2010). Although the major role played by the informal raw milk market in Swaziland is greatly appreciated, previous reports have indicated that raw milk produced by Swaziland farmers may be of poor hygienic quality (Dlamini *et al.,* 1997; Fakudze and Dlamini, 2001). This study attempted to answer the key question; is consumer raw milk sold in retail outlets in Swaziland safe or a public health hazard?

MATERIALS AND METHODS

Source and collection of samples

Milk samples were purchased from seven randomly selected raw milk retail outlets around Manzini-Malkerns corridor. Milk in the retail outlets was supplied by different farmers. Milk in retailers 6, 4 and 5 were from the same source. Retailers 3 and 7 were also supplied by another but same supplier while milk in retailers 2 and 1 came from two different sources. A total number of 56 x 250 mL samples were collected from the retailers that sell raw milk directly to consumers. Milk samples were aseptically collected using 250 mL sterilised Duran screw-cap bottles. The samples were labelled with the name of the source after collection. Temperature of milk samples were measured immediately after sampling at retail outlets using a digital thermometer. Milk samples were transported to the laboratory in an ice-cooler container maintained at temperatures lower than 4^{o}C and in the laboratory the samples were stored in a refrigerator at temperatures lower than 4^{o}C. Laboratory analyses were done within 24 hours of collection.

Public health hazard analysis

Antibiotic residues were determined using the Delvotest® set (Gist-brocades, Delft, The Netherlands) and positive detection levels were determined by the use of sensitivity levels claimed by the manufacturer (Hillerton *et al*., 1999). The presence of index organism (*Escherichia coli*) was detected by enrichment, isolation and confirmation tests as described by Dlamini (2005). *Escherichia coli* presence in milk samples was also quantified by the use of the spread plate counts technique on Eosin Methylene Blue (EMB) agar. Samples were incubated at 45^{o}C for 24 hours and only samples having sheen green metallic colonies were counted.

Freshness tests

The total plate counts were determined by using the spread plate technique described by Dlamini (2005). Yeastreal Milk Agar (Oxoid, Ltd, England) was used as plating media; sample dilutions were done on ¼ strength ringer solutions (Oxoid, Ltd, England). Plates were incubated at 30°C for 72 hours prior to counting colonies. The procedure for determination of total psychrophiles was conducted as described for the total plate counts except that the plates were incubated at 7^{o}C for 10 days.

Total coliform counts were enumerated on MacConkey agar with crystal violet (Bio-lab Diagnostics (Pty) Ltd) using the basal and overlay method (Hartman *et al.*, 1975). Plates were incubated at 37^{o}C for 48h.

Yeasts and moulds were enumerated by the simple plating technique as described by Dlamini (2005). Milk sample dilutions were spread on plates containing Malt Extract Agar (MEA). Plates were incubated at 25^{o}C for 7 days, and then examination and counting of colonies was done. Yeast was confirmed by staining with methylene blue and examined under the compound microscope (Olympus, Tokyo) at 40X magnifications. Titratable acidity and Resazurin (10 min) tests were conducted using methods outlined by International Livestock Research Institute (ILRI) (1995).

Adulteration analysis

The specific gravity of the milk was determined using the lactometer method as outlined by ILRI (1995). Butter fat determination in the milk samples was conducted using the Gerber test method as described by Dlamini (2005). Total solids and solids non fats were determined using methods outlined by ILRI (1995).

Statistical analysis

Micro Soft Excel 5.0 (Micro Soft Corporation Inc., 2003) was used in preparing bar graphs of Log_{10} bacteria counts. The analysis of variance for comparing means was carried out using one-way ANOVA model (MSTAT-C V2.00). The Duncan Multiple Range Test (DMRT) was used to determine significant differences among means at 95% confidence level ($P < 0.05$).

RESULTS

Total bacterial counts

Raw milk samples were bought from the seven retail outlets and received in the same manner as they were sold for public consumption. The results in Figure 1 reflect poor hygienic practices in production and handling of the raw milk sold by a majority of retailers. Milk from retailer 6 had the highest total bacterial counts (5.2 x 10^7cfu/mL). This was significantly higher ($P < 0.05$) than retailers 4, 2, 7 and 1, but was not significantly different ($P > 0.05$) from the other raw milk retail outlets. Milk from retailer 1 had the lowest total bacterial counts (5.5 x 10^5 cfu/mL), which implies better hygienic practices in production but it was not significantly different ($P > 0.05$) from retailers 3, 4, 2 and 7.

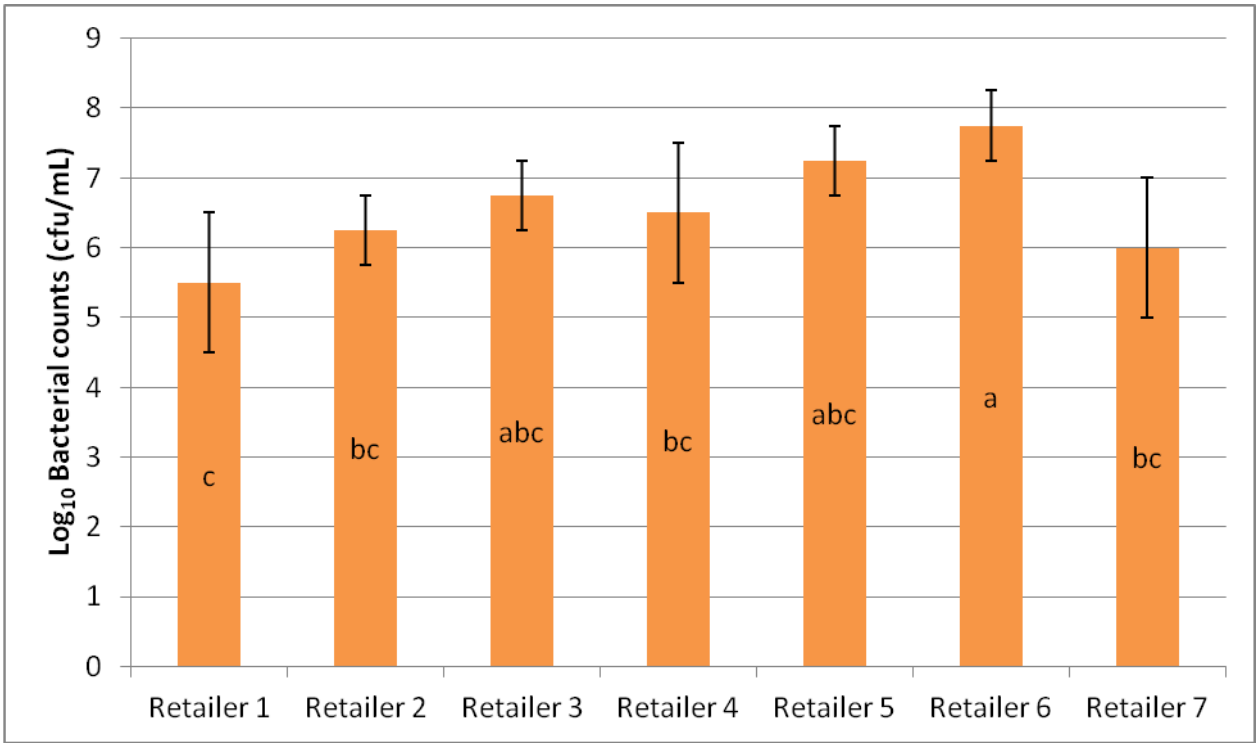

Figure 1: Total bacterial counts for milk samples obtained from the retail outlets using Yeastreal Milk agar as a growth media.
Y error bars = ±1 standard deviation
NB: Bars with different letters are significantly different ($P < 0.05$) from each other

Psychrotrophic bacterial counts

The results shown in Figure 2 indicate that psychrotrophic bacteria were a dominant flora in the total bacterial counts (TBC). Milk from retailer 6 remained the worst performer, having psychrotrophic bacterial counts of 1.1 x 10^7cfu/mL which was significantly different ($P < 0.05$) from retailers 1 and 2. Raw milk from retailer 1 had the lowest psychrotrophic counts (3.1 x 10^4 cfu/mL) which were significantly different from all the other retail outlets. However, there was no significant difference ($P > 0.05$) in psychrotrophic bacterial counts among retailers 2, 4, 7, 3 and 5.

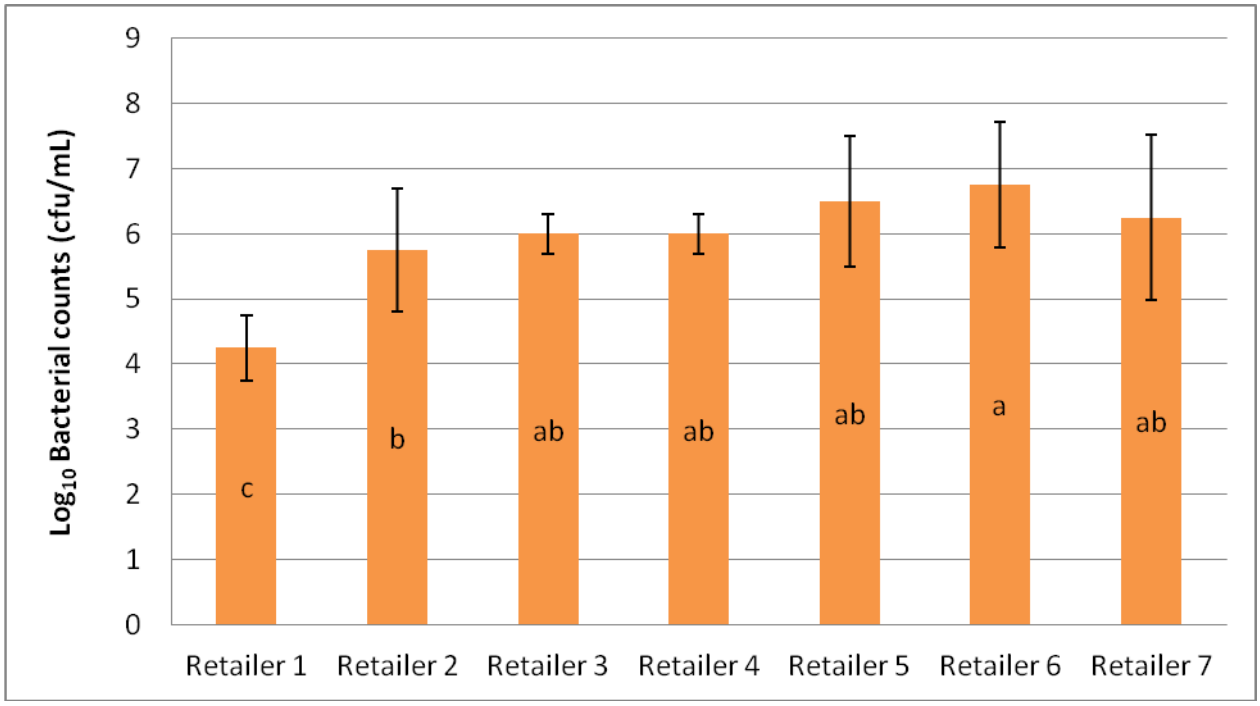

Figure 2: Psychrotrophic bacterial counts for milk samples obtained from the retail outlets using Yeastreal Milk agar as a growth media.

Y error bars = ±1 standard deviation

NB: Bars with different letters are significantly different ($P < 0.05$) from each other.

Coliform bacterial counts

Coliform bacteria counts in all the milk samples (Fig. 3) exceeded the international standard (100 cfu/mL), which is evidence of unsatisfactory milking and milk handling hygiene. Coliforms include bacteria of the *Enterobacteriaceae* family that are normally found in the alimentary canal of warm blooded animals, so their presence is an indicator of possible faecal contamination (Murphy and Boor, 1997; Dlamini, 2005). Based on the results presented in Figure 3, retailer 5 had the highest (2 x 10^6cfu/mL) coliform counts which was significantly different ($P < 0.05$) from retailer 1 which had the least coliform counts (9.9 x 10^4cfu/mL). Even though milk from retailer 1 had the lowest coliform counts, it was not significantly different ($P > 0.05$) from the milk from retailers 2 and 7 which had 4.9 x 10^5 and 5.6 x 10^5 cfu/mL respectively.

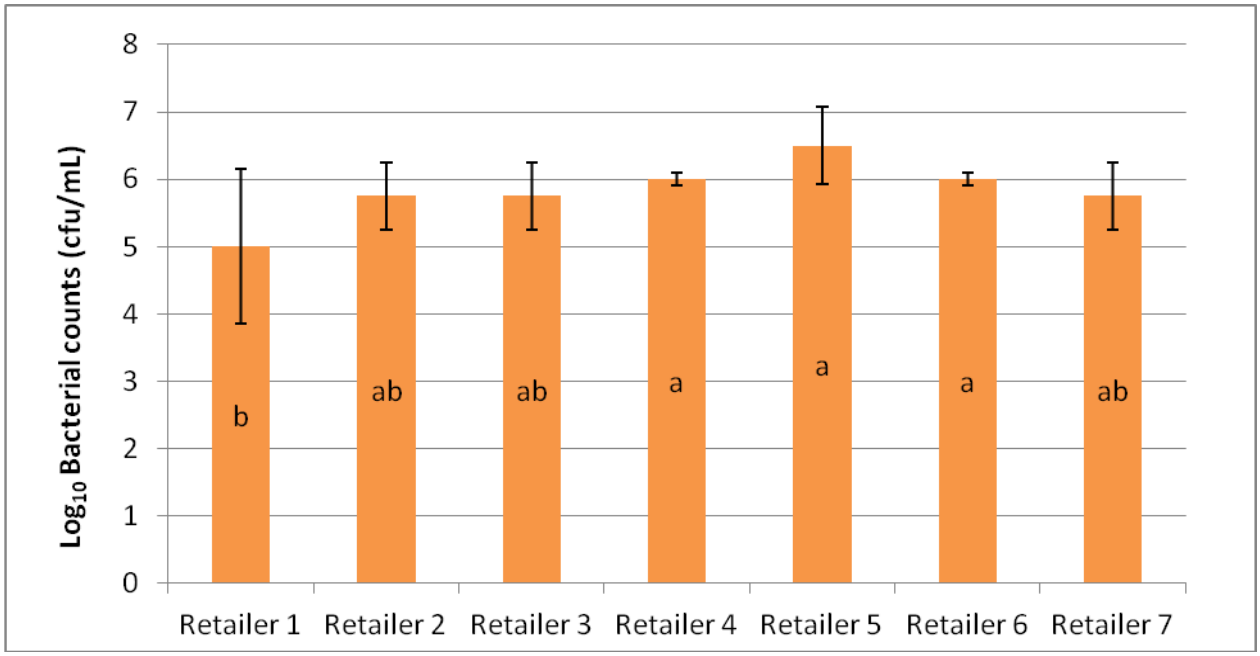

Figure 3: Coliform bacterial counts for milk samples obtained from the retail outlets using MacConkey agar with crystal violet as a growth media.
Y error bars = ±1 standard deviation
NB: Bars with different letters are significantly different (P<0.05) from each other.

***Escherichia coli* (*E. coli*) counts**

All the milk samples obtained from all the retailers tested positive for *E. coli*. This is considered a serious health hazard. *E. coli* is referred to as an index microorganism because its presence implies the possible presence of a similar pathogenic microorganism such as *Salmonella* (Dlamini, 2005). The results in Figure 4 indicate that *E. coli* was the dominant micro flora in the coliform counts, validating the suspicion that the raw milk from the retailers might be contaminated with faeces; milk from retailer 1 had *E. coli* counts more alike to coliform counts (1 x 10^5 cfu/mL), shown in Figure 3. Water pollution as a source of the *E. coli* may not be ruled out (Holm *et al.*, 2004) and this is likely to have emanated from any point between the farms and the retailers. The results showed that retailers 5, 4 and 6 had their *E. coli* counts not significantly different ($P > 0.05$) from each other. However, these were significantly different ($P < 0.05$) from retailers 2 and 3. Raw milk from retailer 2 had the least *E. coli* counts (1.1 x 10^4cfu/mL), although not significantly different ($P > 0.05$) from retailer 3 (1.9 x 10^4 cfu/mL) whereas milk from retailer 5 yielded the highest (3.8 x 10^5 cfu/mL) *E. coli* counts.

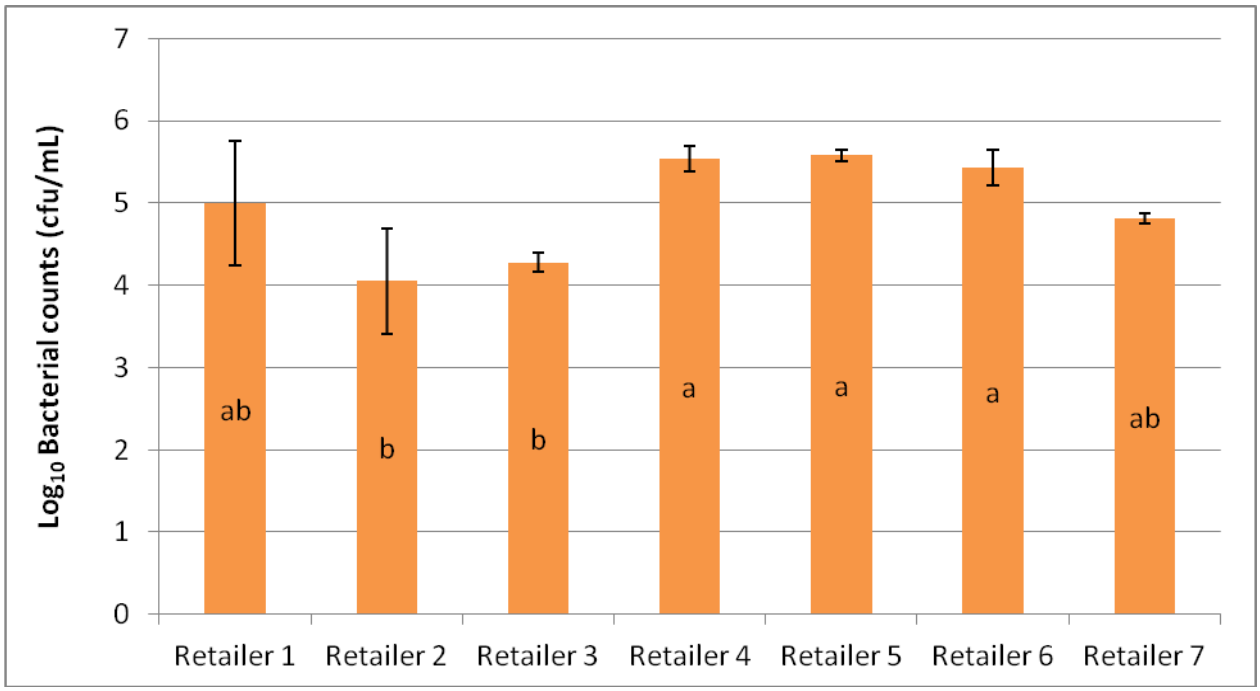

Figure 4: *E. coli* counts for milk samples obtained from the retail outlets using Eosine methylene blue agar as a growth media.
Y error bars = ±1 standard deviation
NB: Bars with different letters are significantly different (P<0.05) from each other.

Yeast and moulds counts

All the milk samples analysed reflected possible contamination by feed (van den Berg, 1988). Yeast and moulds are undesirable for the processing quality of the milk. Milk from retailer 6 had higher (2.7 x 10^6 cfu/mL) yeast and moulds counts which was significantly different (P < 0.05) from retailers 7, 3 and 1, but it was not significantly different (P > 0.05) from the other retail outlets. There was also no significant difference (P > 0.05) between retailers 5, 4 and 2. Raw milk from retailer 1 had the least (1.4 x 10^5 cfu/mL) yeast and mould counts
.

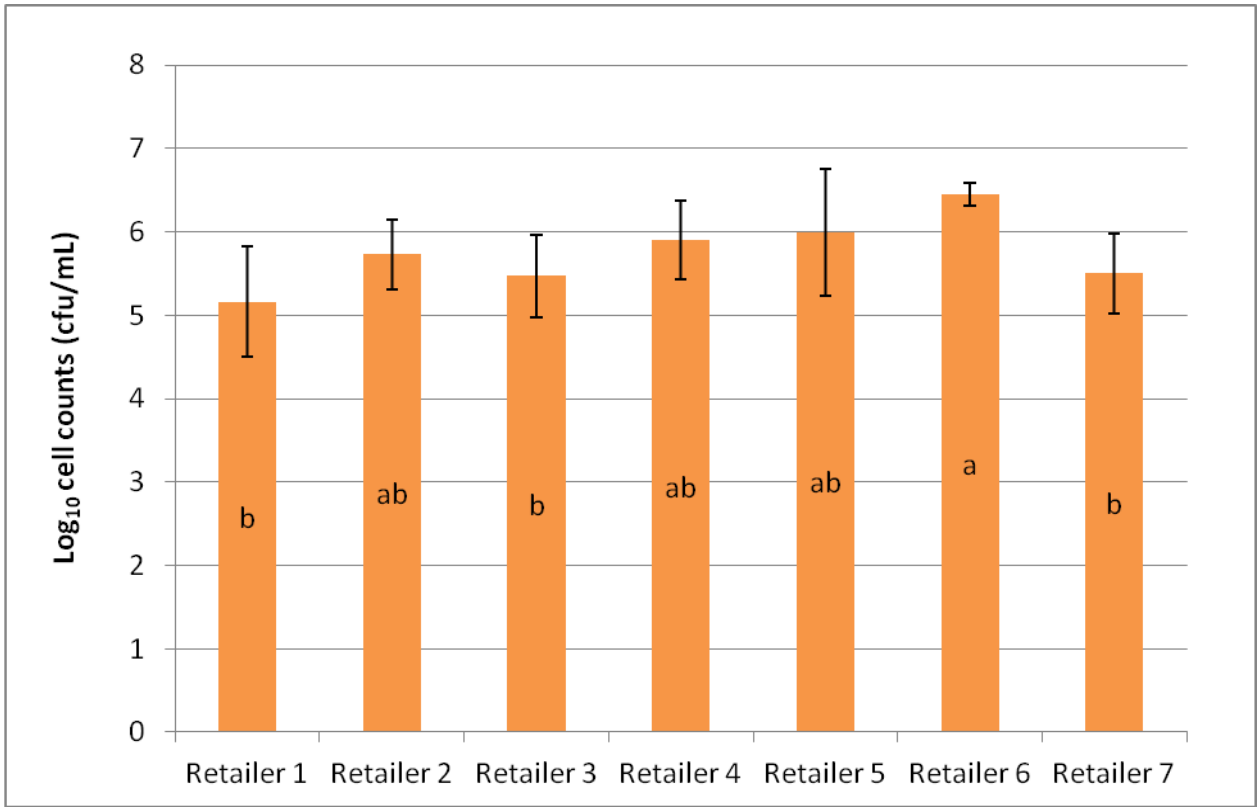

Figure 5: Yeast and moulds counts for milk samples obtained from the retail outlets using malt extract agar as a growth media.

Y error bars = ±1 standard deviation

NB: Bars with different letters are significantly different (P<0.05) from each other.

Butter fats percentage (%)

Data obtained from the study showed a wide variability in butter fat percentage among the retail outlets, which implies that consumers get different qualities of raw milk. As it can be seen in Figure 6, milk from retailers 3, 2 and 7 had a mean deviation of 2.875 ±1.69, 4.75 ±1.56 and 3.575 ±1.12% (w/v) respectively. Raw milk from retailer 3 had its average butter fat percentage lower than the minimum (3.0% w/v) accepted as normal for bovine milk. The differences in butter fat percentage were also influenced by the different suppliers as expected. Milk from retailer 2 had the highest butter fat content of 4.5 % (w/v), but it was not significantly different (P>0.05) from retailers 1, 4, 7, 6 and 5.

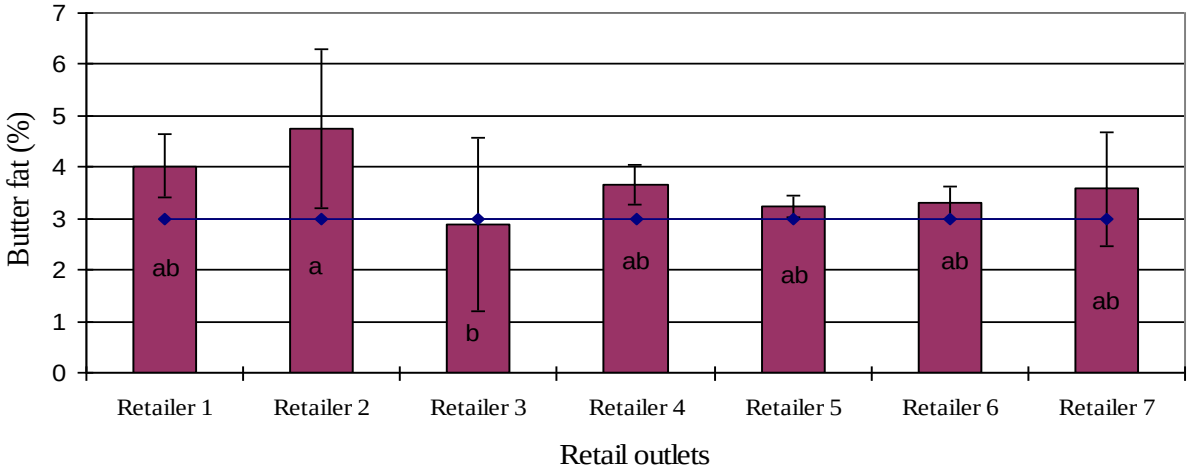

Figure 6: Butter fat percentage (%) for milk samples obtained from the retail outlets.
Y error bars = ±1 standard deviation
NB: Bars with different letters are significantly different ($P < 0.05$) from each other.

Specific gravity

According to ILRI (1995), normal cows' milk should have a specific gravity between 1.028 and 1.032 g/cm^3. It can be seen from the results presented in Figure 7 that raw milk from retailers 7 and 1 had the highest specific gravities of 1.032g/cm^3. Milk from retailer 2 had specific gravity lower than the minimum level, 1.025g/cm^3. This corresponded to 5% water addition

.

Figure 7: Specific gravity of milk samples from retail outlets around Manzini

Titratable acidity

The results for milk freshness test are presented in Figure 8. In all the samples from the retail outlets, the milk had lactic acid levels above the standard maximum acceptable level for fresh milk, 0.22 % (v/v). This implies that the milk offered for sale at these retail outlets is not fresh and is therefore of poor processing quality. Milk from retailer 7 had the highest lactic acid percentage (0.343%) while retailer 2 had the least lactic acid content (0.246%) in its milk.

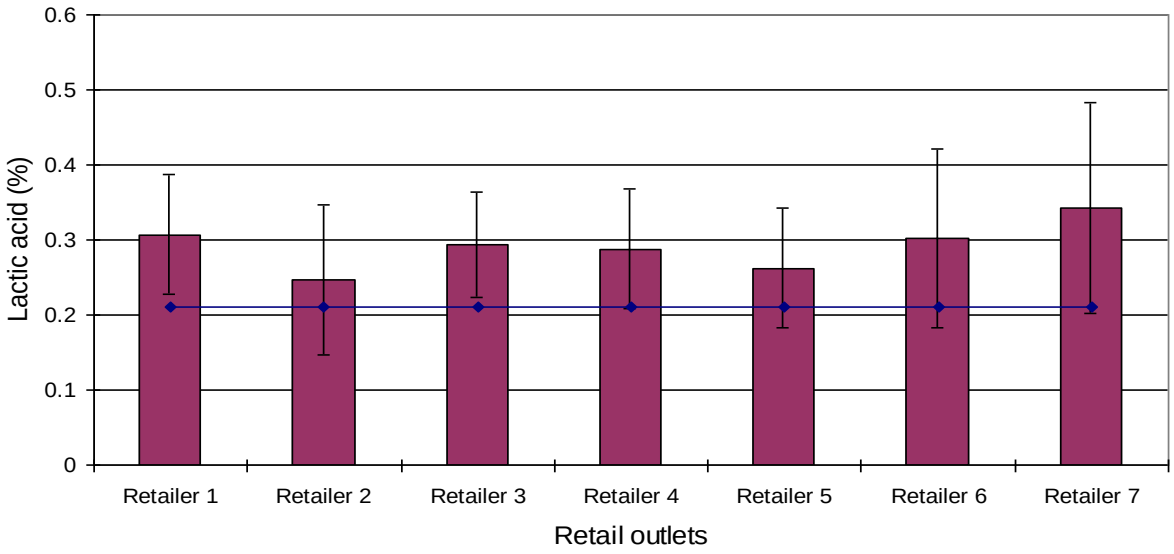

Figure 8: Titratable acidity for milk samples of raw milk sold by retailers around Manzini
Y error bars = ±1 standard deviation

Temperature

The results in Figure 9 shows that temperatures of milk samples from all the retailers were above the standard maximum storage temperature of 10^{o}C for raw milk. There was a great variation among the retail outlets in milk storage temperature, with milk from retailer 1 having the highest (26.3^{o}C) temperature recording while retailer 6 had the lowest (12.3^{o}C). Temperatures above 10^{o}C are understood to increase bacterial counts at least four times as fast at 4^{o}C which then lead to biological changes of milk fat, protein and sugar (van den Berg, 1988).This is a health hazard because most pathogenic bacteria are psychrophiles, therefore they can multiply rapidly under such temperatures.

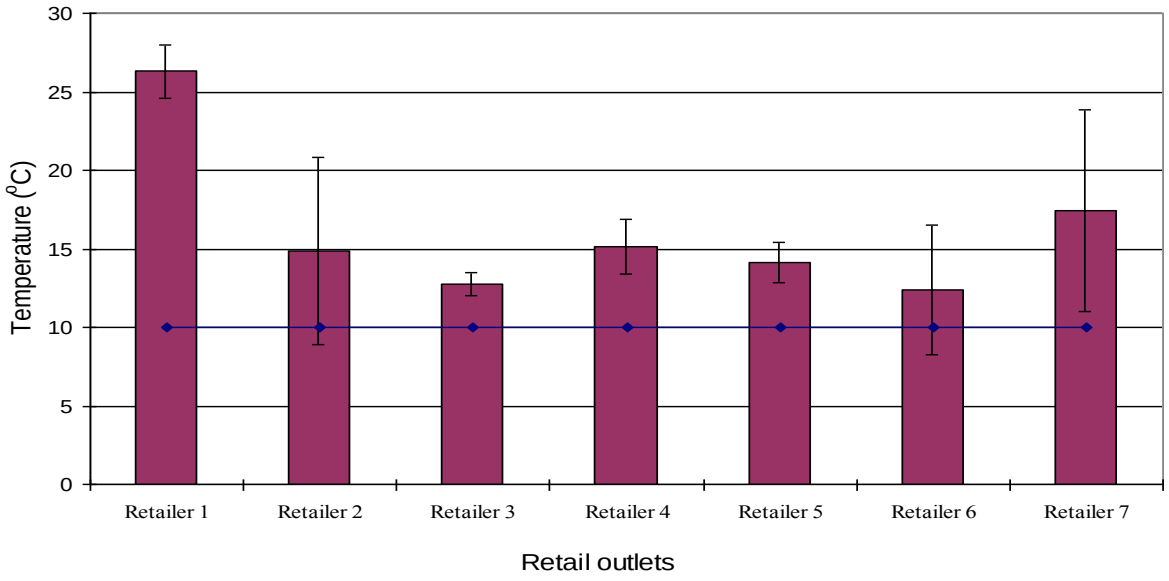

Figure 9: Temperature obtained from milk samples of raw milk sold by retailers around Manzini
Y error bars = ±1 standard deviation

Antimicrobial residues

It is normal that lactating cows are occasionally treated for diseases using veterinary pharmaceuticals, particularly if mastitis occurs. Residues of medicine are secreted in the milk by the organism of the animal (van den Berg, 1988). Legally registered veterinary pharmaceutical drugs used to treat food producing animals are packaged with leaflets informing the end user of the mandatory drug withdrawal period, post administration, within which human consumption of the treated animal or its products is unsafe and prohibited. However, results for detection of antimicrobial residues in milk samples from the retail outlets indicated that consumption of raw milk from these retailers is a serious health hazard. Out of all the samples analysed, 82.1% (Table 1) contained antimicrobial residues above the accepted positive sensitivity levels

.

Table 1: Overall results for antimicrobial residues in raw milk from retail outlets around Manzini.

Results	Frequency	Percentage (%)
Positive	23	82.1
Negative	5	17.9
Total	28	100

DISCUSSION

Hygienic quality

The results obtained during this work on the indicators of raw milk hygienic quality have shown that the current situation is bad and needs real improvement. Hygienic milk quality was generally poor, as judged by total bacterial, psychrotrophic and coliform counts which were significantly higher than the international standards for safe human consumption. Milk samples from retailer 1 had a TBC around ($1x10^5$) cfu/mL. This may suggest that there is better implementation of hygienic practices in milking, handling, storage and shop dispensation of the raw milk by this retailer compared to the other retailers. All the other retail outlets had their TBC above the maximum standard (10^6cfu/mL) considered safe for human consumption in raw milk, (Gilmour and Rowe, 1990). Holm *et al.*(2004) suggested that high TBC can be influenced by poor storage temperature, long storage period after milking, health and hygiene of the cow, environment where milking is done as well as procedures used in cleaning and sanitising the milking and storage equipment. Figure 9 indicated that storage temperatures in the bulk tanks at the shops were very high and probably contributing to microbial growth. Results presented in Fig. 1 shows that milk from retailer 6 had the highest (5.2×10^7 cfu/mL) TBC which indicates evidence of serious faults in production and storage hygiene. These results are incongruous with previous studies (Dlamini *et al*., 1997; Fakudze and Dlamini, 2001). This shows that in general raw milk from the retailers was of poor hygienic quality.

Results presented in Figure 2, have shown that milk from retailer 6 had the highest (1.1×10^7 cfu/mL) psychrotrophic bacterial counts among all the retailers while retailer 1 had the lowest counts (3.1×10^4). Psychrotrophic bacterial counts could indicate occasional neglect of proper cleaning or sanitising procedures, water pollution and long storage periods (Murpy and Boor, 1997). These results infer that the raw milk could possibly be kept in the bulk tanks for prolonged periods (>48 hours) or that the bulk tanks are not cleaned properly.

Coliform and *E. coli* counts reached up to 2×10^6 cfu/mL and 3.8×10^5 cfu/mL respectively, which may suggest faecal contamination from dirty cows as well as milk residues from dirty equipment. There is a possibility of polluted water being a source of the coliform bacteria consisting of *E. coli* as Holm *et al.* (2004) reported it to be widely accepted to indicate water pollution. Environmental mastitis can also be a source as it is associated with high coliform counts

in raw milk in bulk tanks (Murphy and Boor, 1997). The coliform counts from this study was found to have increased from the value (9.9×10^4 cfu/mL) previously reported by Dlamini *et al.* (1997). This shows that services offered by Swaziland Dairy Board on clean milking had not been significant perhaps due to other influencing factors such as socio-economic status of farmers. This calls for the dire need to implement other alternative strategies to correct the problem. The presence of a high population of the index microorganism, *E. coli*, in the raw milk samples definitely validates the suspicion that the consumption of raw milk in the country could be a serious health hazard. As reported by Dlamini (1990; 2005), presence of *E. coli* indicates that other similar pathogenic bacteria could be present in the milk.

Compositional quality

Total solids and solids non fats content of the milk was almost normal in all the milk samples from the different retail outlets. All the retailers had total solids and solids non fats content of their milk around the average for normal milk, 12% (w/v) and 8% (w/v) respectively. There was a wide variation in the butter fat percentage among samples taken from the retail outlets during the study period. Variations in butter fat percentages among milk can be attributed to breed, lactation stage and fibre fraction of diet (ILRI, 1995; van den Berg, 1988). Results in Figure 6 showed a wide variability in butter fat percentage; milk from retailers 3, 2 and 7 with range of 2.875 ±1.69, 4.75 ±1.56 and 3.575 ±1.12 respectively. The difference in fat content among the suppliers could also be attributed to genetic influence as retailers 2 and 1 sell Jersey milk while milk from the other retail outlets came from the Friesian breed. The variation in the fat content of the milk in these retail outlets can also be attributed to poor agitation in milk shop cooler tanks as it was observed that most of the tanks for milk storage in the city had no stirring facilities. The result of poor milk agitation in the dispensing milk cooling tanks is the same as the milk sold to the public. In the absence of agitation, the milk fats settle on the top surface of the milk in the tanks since the fats have a lower density than the rest of the milk components, resulting in a watery consistency of the milk at the bottom of the tanks.

Illegal practices

Results of milk freshness test presented in Figure 8 shows that all milk samples from the retail outlets had lactic acid above the standard (< 0.22%) for fresh milk. This may suggest poor sanitisation of storage tanks as well as addition of fresh milk to storage tanks already containing milk stored for 24 hours or longer. This is a health hazard to the public because the milk can no longer be pasteurised as it can curdle. The high values of lactic acid percentage in the raw milk samples can be attributed to the poor cooling of the milk (van den Berg, 1988). This assumption is supported by the mean temperature readings of raw milk in the different retailers (Figure 9), all readings were above the standard maximum temperature requirement for raw milk (10^oC) which is required to suppress growth of lactic acid bacteria.

Results presented in this research (Figure 7) have shown that milk from retailer 2 had very low specific gravity, $1.025 g/cm^3$. This suggested that this milk was possibly adulterated by addition of at least 5% (v/v) water. Adulteration is a possible health hazard because it may result in contamination with water-borne pathogens and toxic chemicals (Omore *et al.*, 1999). It also reduces the palatability and market value of the milk in the sense that added water dilutes the sweetness, potentially resulting in a "flat" taste so consumers do not derive the desired satisfaction from milk.

Safety of raw milk

The presence of *E. coli* in the raw milk sold to the public might be a health hazard as its presence implies presence of similar pathogenic bacteria such as *Salmonella* and other pathogenic *Enterobacteriaceae* (Dlamini, 1990; 2005). Results presented in Figure 4 show that *E. coli* counts in the tested samples reach 3.8 x 10^5 cfu/mL, this is an indication that milk samples were contaminated with faecal coliforms (Murphy and Boor, 1997). The recommended practice of pasteurising milk can help to destroy such harmful pathogens and largely eliminates public health risks. Yeast and moulds counts reached 2.7 x 10^6 cfu/mL, indicating poor hygienic quality of the milk and making it a potential health hazard to the public consuming it. The yeast and moulds present in the milk may have originated from the cattle being fed mouldy feed or they could have been introduced from the air-borne spores anywhere between the farms and the retailers. The presence of yeast and moulds in the milk is not only undesirable but is also considered a health hazard because fungi like *Aspergillus spp* usually produce Aflatoxins, which are toxic to humans (van den Berg, 1988).

The overall drug residue frequency levels indicate that a consumer who takes this raw milk daily is at risk of consuming milk with sub therapeutic levels of antibiotics and therefore in danger of developing drug resistant bacterial infections. Table 1 indicate that in all the samples obtained from the different raw milk retail outlets around Manzini, 82.1% of them were containing antimicrobial residues as they detected positive on unacceptable levels hence posing a serious health hazard to the consumers. There was no significant difference ($P > 0.05$) in antibiotic level of milk supplied by the same supplier. This indicated that antimicrobial residues in marketed milk originated at the farm level. This may suggest that farmers do not observe the withdrawal periods after treatment of dairy cows. Roca *et al*. (2011) emphasise that antibiotics are a serious health hazard as they are not completely destroyed by boiling or pasteurisation. Evidence indicates that consumption of milk that has antibiotic residues is harmful because it may result in development of drug resistant pathogens, and may also result in allergic reactions (van den Berg, 1988; Bischoff *et al.,* 2003). In addition to the human health concerns, the presence of antibiotic residues in milk is undesirable because of their interference with starter cultures added in milk during processing hence preventing the fermentation of the milk into the desired dairy product.

CONCLUSIONS

This study revealed that the hygienic quality of raw milk sold to consumers by retail outlets around Manzini was poor. It also confirmed that raw milk from these retail outlets may be a serious health hazard to the public as the main indicators used were found to be far above international standards considered to be safe for human consumption. The hygienic quality of the milk sourced from the retailers in this study may be a result of poor cleaning and sanitising of milking and storage equipment, poor storage temperatures, long storage periods after milking, and poor hygiene and health of milking cows and farm personnel. Urgent measures are needed to ensure safe raw milk at public level by promoting good hygienic practices at farm and market level. These should preferably focus on appropriate milking methods, efficient cleaning of milking equipment using appropriate detergents and water and strictly adhering to manufactures instructions on the withdrawal periods in the use of antibiotics for herd health. There must be an intense and routine testing and evaluation of the milk quality sold by these retailers to the public by the relevant competent authorities. Consumers should be warned to heat treat

their raw milk prior to consumption. This should be accompanied by tough penalties and withdrawal of permits where retailers are found to be deliberately contravening the public health, food safety regulations.

RECOMMENDATIONS

It is suggested that efforts should be made to strengthen the quality control system in the country. This can be done by creating awareness about public safety to all stakeholders, training and offering advice to farmers so that farmers can have efficient external expertise at their disposal. The combination of the expertise influence and support can then be completed with a system to trace incidental quality deviations and prevent the milk concerned from entering the market. Consumers should be encouraged to ensure that all purchased milk is appropriately heated (boiled or pasteurised) before consumption in order to mitigate bacteriological health hazards. This may be enforced through appropriate media campaigns.

In order to improve milk quality, informal traders should be trained, certified and licensed to sell raw milk of acceptable quality. This would gradually incorporate them to the formal milk market and allow for greater monitoring and control of their activities. The modification of milk shop cooler tanks is necessary to eliminate variation in composition of raw milk sold to consumers. These storage tanks should have a stirring mechanism for agitation of the milk so as to ensure even distribution of milk fat globules in the milk and the sale of a homogenous product to the public.

LITERATURE CITED

Andrew, S. M., Frobish, R. A., Paape, M. J. and Maturin, L. J. (1997). Evaluation of selected antibiotic residue screening test for milk from individual cows and examination of factors that affect the probability of false positive outcomes. *Journal of Dairy Science.* 80: (11) 3050-3064.

Anonymous. (2003). How do milking conditions affect the hygienic quality of raw milk? Case study from Moroccan dairy farms. Vol.18**:** (7). *htt://www.cipav.org.co/lrrd18/7/cont1807.htm*. 12/03/2007.

Batt, C.A. (1996). Molecular diagnostics for dairy-borne pathogens. *Journal of Dairy Science.* 80: (11) 220-230.

Bischoff, K.M., Edrington, T.S., Callaway, T.R., Genovese, K.J., Beier, R.C. and Nisbet, D.J. (2003). Antimicrobial resistance in Salmonella isolated from dairy calves in Texas [abstract]. *National Foundation for Infectious Disease.* p. 44.

Cody, S. H., Abbot, S. L., Martin, A. A., Schulz, B. and Wagner, P. (1999). Two outbreak of multidrug- resistant Salmonella, Serotype Typhimurium DT-104 infectious linked raw-milk cheese in Nothern California. *Journal of American Medical Association* 281**:** 1805-1810.

D'Amico, D. J. and Donnelly, C. W. (2010). Microbiological quality of raw milk used for small-scale artisan cheese production in Vermont: Effect of farm characteristics and practices. *Journal of Dairy Science* 93: 134–147.

Dlamini, A. M. (1990). *Studies on the effect of temperature on the activity of the Lactoperoxidase system in bovine milk.* Unpublished M.Sc. Thesis, University of Glasgow, Scotland.

Dlamini, A. M. (2005). Guidelines for the establishment of a quality control laboratory for Swaziland Dairy Board**.** *A document prepared on behalf of Swaziland Dairy Board.*

Dlamini, A.M., Shandomo, M.N. and Hadebe, M. (1997). Bacteriological Quality of consumer's milk in the Malkerns Valley dairy farmers of Swaziland. *UNISWA Journal of Agriculture, Science and Technology* 6:36-42.

Fakudze, F. M. and Dlamini, A. M. (2001). Composition and hygienic quality of consumer milk from shops in Swaziland. *UNISWA Journal of Agriculture* 5: (2)169-176.

FAO (1990). The technology of traditional milk production in developing countries. *FAO animal production and health paper:* 85, Rome, Italy.

FAO (2003). Livestock production policy in Swaziland: Achievements, constraints and options. *Government of Swaziland, FAOTCP/SWA/2907 and UNDP***.**

Gall, D. and Nielsen, K. (2004). Serological diagnosis of *Bovine brucellosis*: A review of test performance and cost comparison. *Revue Scientifique et International Office of Epizootic.* 23 (3): 989-1002.

Gilmour, A. and Rowe, M. T. (1990). *Micro-organisms associated with milk.* In: Robinson, R. K.(2ed) *Dairy microbiology*. Volume 1, *The microbiology of milk.* Elsevier Applied Science, London and New York.

Hartman, P. A., Hartman, P. S. and Lanz, W.W. (1975). Violet red bile agar for stressed coliforms. *Applied Microbiology* 29: 537-539.

Hillerton, J. E., Halley, B.I., Neaves, P. and Rose, M.D. (1999). Detection of antimicrobial substances in individual cow and quarter milk samples using Delvotest microbial inhibitor Test. *Journal of Dairy Science* 82: 704-711.

Holm, C., Mathiasen, T. and Jesperson, L. (2004). A flow cytometric technique for quantification and differentiation of bacteria in bulk tank milk. *Journal of Applied Microbiology* 97: (5) 935-941.

ILRI (1995). *Rural dairy technology.* International Livestock Research Institute, International Livestock Centre, Ethopia.

Jayarao, B. M. and Henning, D. R. (2001). Prevalence of food-borne pathogens in bulk tank milk. *Journal of Dairy Science* 84: 2157-2162.

Masarirambi, M.T., Mhazo, N., Dlamini, A.M. and Mutukumira, A.N. (2009). Common indigenous fermented foods and beverages produced in Swaziland. *Journal of Food Science and Technology* 46: 505 – 508

Matthewman, R.W. (1993). *Dairying*, University of Edinburgh, Scotland, UK.

Microsoft. (2003). Microsoft 5.0. Micro Soft Corporation Inc. Redmond, Washington.

Murinda, S.E., Nguyen, L.T., Man, H.M. and Almedia, R.A. (2004). Detection of sorbitol negative and sorbitol-positive shiga toxin-producing *Escherichia coli*, *Listeria monocytogenes*, *Campylobacter jejuni* and *Salmonella* species in dairy farm environments. *Food-borne Pathogens and Disease* 1: 97-104.

Murphy, S. C. and Boor, K. J. (1997). Sources and causes of high bacteria counts in raw milk: An abbreviated review, *Dairy Science Facts*, Cornell University, Ithaca, NY. *http://www.foodscience.cornell.edu*. 25/06/2006.

Oliver, S.P., Jayarao, B.M. and Almedia, R.A. (2005). Food borne pathogens in milk and the dairy environment food safety and public health implications. *Foodborne Pathogens and Disease* 2: 1115-1129.

Omore, A., Lore, T., Staal, S., Kutwa, J., Ouma, R., Arimi, S. and Kang'ethe, E. (1999). Addressing the public health and quality concerns towards marketed milk in Kenya. *Small holder dairy project, SDP research and development* report 3, Kenya. *http://www.smallholderdairy.org*. 24/06/2006.

Roca, M., Villegas, L., Kortabitarte, M. L., Althaus, R. L. and Molina, M. P. **(**2011). Effect of heat treatments on stability of β-lactams in milk. *Journal of Dairy Science* 94 :1155–1164.

Scott, D.S. (1998). Why Pasteurize? The dangers of consuming raw milk. *Dairy Science Facts***,** Cornell University, 607/255-7922. *http://www.foodscience.cornell.edu*. 24/06/2006.

Swaziland Dairy Board (SDB) (2010). Swaziland Dairy Board Annual Report. *Swaziland Dairy Board,* Manzini.

van den Berg, J. C. T. (1988). *Dairy technology in the tropics and subtropics*. PUDOC, Wageningen.