THE EFFECT OF MANAGEMENT ON MASTITIS INCIDENCE IN DAIRY COWS IN QWAQWA

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Dissertation submitted in partial fulfilment of the requirements for the degree

***MAGISTER TECHNOLOGIAE*:**
AGRICULTURE: ANIMAL PRODUCTION

In the

Faculty of Health and Environmental Sciences
School of Agriculture and Environmental Sciences

At the

Central University of Technology, Free State

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DECEMBER 2005

DECLARATION OF INDEPENDENT WORK

I, **LIMPHO KEKELETSO TAOANA**, identity number [redacted] and student number 20374941, do hereby declare that this research project submitted to the Central University of Technology, Free State for the degree *MAGISTER TECHNILOGIAE*: AGRICULTURE is my own independent work; and complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology; and has not been submitted before to any institution by myself or any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

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ACKNOWLEDGEMENTS

I wish to express my sincere thanks and gratitude to the following: My Creator, God, who gave me the strength and courage to complete this study successfully. Special thanks are due to Dr. S.D. Mulugeta, my academic supervisor, for his willingness to guide the study, for the statistical analysis of the data, his constructive comments on the writing of this thesis and thank you so much for many hours and weekends you devoted to my study. Not to forget my co-supervisors Dr P.J. Fourie and Prof. C. van der Westhuizen for their suggestions and comments. I would like to express my special gratitude to all farm managers who participated in this study for their time during the collection of the questionnaire data and giving access to their cows to collect milk samples. Mr. T. Phalatsi (Animal Health Technician) is thanked for introducing me to farmers and with his help I was able to reach all farms. I thank the University of the Free State, QwaQwa campus for allowing me make use of their vehicle to reach all the farms. I thank Mr. E. Mjiyakho for his technical expertise in all the analyses of milk samples at Nestle Harrismith. Mr. T. Jobo, from the Library and Information Centre at the Central University of Technology for his willingness and generous help during the literature searching and Ms. A. Du Toit is also thanked. This study was made possible by the Innovation Fund of the Central University of Technology, Free State for granting the funding. Since it is not possible to mention every one, may I generally with thanks reach out to all who contributed to the success of my study.

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LIST OF ABBREVIATIONS

Abbreviation	Term in full
BCS	Body condition score
BMSCC	Bulk milk somatic cell count
CM	Clinical mastitis
CMT	California Mastitis Test
CNS	Coagulase negative staphylococci
CFU's	Colony forming units
GLM	General linear model
Ha	Hectare
IMI	Intra-mammary infection
IRCM	Incidence rate of clinical mastitis
LF	Left front
LR	Left rear
PMTD	Post milking teat disinfection
RF	Right front
RR	Right rear
SAS	Statistical analysis system
SCC	Somatic cell count
SCM	Sub-clinical mastitis
SE	Standard Error
SNF	Solids not-fat
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Unit
TPC	Total Plate Count
TRC	Transitional rural council
UHS	Udder Hygiene Score

ABSTRACT

A study on the effect of certain management practices on mastitis incidence in dairy cows in the QwaQwa area situated in the north-eastern region of the Free State Province was undertaken during the period of November and December 2003. The study had the following main objectives: To study the level of the mastitis problem and farmers' knowledge regarding mastitis control on dairy farms in QwaQwa; and to determine the effect of somatic cell count (SCC) on milk components. An individual questionnaire was used to collect data from sixty randomly selected small-scale dairy farmers. A total of 120 lactating cows from 30 selected farms were examined for SCC using the California mastitis test (CMT) kit in the farms and Fossomatic counter machine in the laboratory. The purpose of the questionnaire survey was to gather information on the farm and its management practices, while clinical examination using the Fossomatic machine and CMT screening was used to determine mastitis prevalence. The average age of the participant farmers was 55±13 (SD) years. Only 28% of the farmers had a secondary or tertiary level of education. The average dairy herd size was 39 ±36 (SD) animals. The cows in milk constituted 36% of the herd, while the remainder were dry cows (14%), heifers (16%), calves (30%) and bulls (4%). When farmers were grouped into their daily milk production capacity, 57% reported producing 1 to 50 litres, 20% 51 to 100 litres, and 23% more than 100 litres per day. Only 8.3% of the farmers reported having experienced mastitis problems. The average clinical mastitis cases reported per farm per year were 1.6±1.6 (SD) cases. The average incidence rate of clinical mastitis was 18.5% (calculated as the number of clinical cases divided by the number of cows in milk). As expected, the mastitis cases reported by small-scale dairy farmers showed a positive association with the number of cows in the herd. The incidence of mastitis reported for 1 to 50 litres, 51 to 100 litres and approximately 100 litres daily milk production groups was 20.5%, 24.7% and 8.1% respectively; however, the difference between the groups was not significant due to a large number of sampling errors. No other management practices - such as having a separate milking parlour, washing hands and teats before milking, and using disinfectant on teats - had an influence on the mastitis incidence reported by farmers. On average, the concentration of fat, protein, lactose and SNF in milk was 4.41%,

3.40%, 4.87% and 8.66% respectively. With the exception of parity, all other factors studied (breed, daily milk yield, and udder, rear leg and parlour cleanliness) did not have a significant influence on SCC, TPC, and CMT score ($P>0.05$). The SCC ranged from 198.8 ± 1.4 (cells/ml) for the Jersey breed to 400.3 ± 1.4 (cells/ml) for the Brahman breed. Both SCC and positive CMT increased ($P<0.01$) from first to fourth parity. Amongst milking management factors, washing of hands made a significant difference ($P<0.05$) to CMT and TPC count. No other management and animal-related factors studied had an influence on milk components ($P>0.05$). There was significant positive correlation between SCC and CMT score ($r = 0.6$). Somatic cell count and CMT produced showed significant negative correlations ($r=-0.4$; $r=-0.37$ and $r=-0.4$; $r=-0.39$) with lactose and SNF.

OPSOMMING

‘n Studie oor die uitwerking van sekere bestuurspraktyke op die voorkoms van mastitis in melkkoeie in die Qwaqwa-area geleë in die noordoostelike streek van die Vrystaat is gedurende die periode November-Desember 2003 onderneem. Die hoofdoelwitte van die studie was die volgende: Om die omvang van die mastitisprobleem en die boere se kennis mbt mastitisbeheer op suiwelplase in Qwaqwa te bestudeer; en om die effek van somatiese seltelling (SST) op melkkomponente te bepaal. ‘n Individuele vraelys is gebruik om inligting van sestig ewekansig geselekteerde kleinskaalse melkboere in te samel. ‘n Totaal van 120 lakterende koeie op 30 geselekteerde plase is ondersoek met die oog op SST deur die Kaliforniese mastitis-toets-toerusting (KMT-toerusting) op die plase en die Fossomatiese tellingmasjien in die laboratorium te gebruik. Die doel van die vraelysopname was om inligting oor plase en hul bestuurspraktyke in te samel. Kliniese ondersoeke met behulp van die Fossomatiese masjien en KMT-sifting is aangewend om die voorkoms van mastitis vas te stel. Die gemiddelde ouderdom van die deelnemende boere was 55±13 (SA) jaar. Slegs 28% van die boere het oor ‘n sekondêre of tersiêre vlak van opvoeding beskik. Die gemiddelde grootte van ‘n melkkudde was 39 ±36 (SA) diere. Die melkproduserende koeie het 36% van die kudde uitgemaak, terwyl die res droë koeie (14%), verse (16%), kalwers (30%) en bulle (4%) was. Boere is volgens hul daaglikse melkproduksie-kapasiteit gegroepeer, en hiervolgens het 57% aangedui dat hulle 1 tot 50 liter produseer, 20% 51 tot 100 liter, en 23% meer as 100 liter per dag. Slegs 8.3% van die boere het aangedui dat hulle mastitisprobleme ervaar. Die gemiddelde voorkoms van mastitis was 1.6±1.6 (SA) gevalle per plaas per jaar. Die gemiddelde voorkomssyfer van kliniese mastitis was 18.5% (bereken as die aantal kliniese gevalle gedeel deur die aantal melkproduserende koeie). Soos verwag, het die aantal mastitisgevalle soos aangemeld deur kleinskaalse melkboere, ‘n positiewe assosiasie getoon met die aantal koeie in die kudde. Die voorkoms van mastitis in die daaglikse melkproduksiegroepe van 1-50 liter, 51-100 liter en ongeveer 100 liter was 20.5%, 24.7% en 8.1% onderskeidelik. Die onderlinge verskille tussen die groepe was nie beduidend nie as gevolg van ‘n groot aantal steekproeffoute. Geen ander bestuurspraktyke – soos ‘n afsonderlike melkstal, die was van hande en spene voordat die koeie gemelk word, en die

gebruik van ontsmettingsmiddels op spene – het ‘n invloed gehad op die voorkoms van mastitis soos aangemeld deur boere. Die gemiddelde konsentrasie van vet, proteïen, laktose en VSNV (vaste stowwe, nie-vet) in melk was 4.41%, 3.40%, 4.87% en 8.66% onderskeidelik. Met die uitsondering van pariteit het alle ander faktore wat bestudeer is (ras, daaglikse melkopbrengs en uier-, agterbeen- en melkstalhigiëne), nie ‘n beduidende invloed op SST, TPT en KMT ($P>0.05$) gehad nie. Die SST het gewissel van 198.8 ± 1.4 (selle/ml) vir die Jersey-ras tot 400.3 ± 1.4 (selle/ml) vir die Brahman-ras. Beide SST en positiewe KMT het toegeneem ($P<0.01$) vanaf die eerste tot vierde pariteit. Betreffende die melkbestuursfaktore het die was van hande ‘n beduidende verskil ($P<0.05$) aan KMT- en TPT-tellings gemaak. Geen ander bestuurs- en dierverwante faktore wat bestudeer is, het ‘n invloed op melkkomponente gehad nie ($P>0.05$). Daar was ‘n beduidende positiewe korrelasie tussen die SST- en KMT-tellings ($r=0.6$). Die somatiese seltellings en KMT het beduidende negatiewe korrelasies vertoon ($r=-0.4$; $r=-0.37$ en $r=-0.4$; $r=-0.39$) mbt laktose en VSNV.

CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

Mastitis (from the Greek word "*mastos*", meaning breast or udder, and the suffix "*itis*" meaning breast inflammation) classically is defined as an inflammation of the mammary gland (Kehrli & Shuster, 1994). It is caused by micro-organisms; usually bacteria, which invade the udder, multiply, and produce toxins that are harmful to the mammary gland. Micro-organisms invading the mammary gland via the teat cause 90-95% of mastitis problems, while 5-10% of mastitis problems are due to injury (NebGuide, 2003). Factors contributing to the incidence of mastitis include people, weather, housing conditions (bedding and ventilation), other diseases, and metabolic disorders (NebGuide, 2003). Other factors that predispose animals to mastitis include poor hygiene, poor animal husbandry, the malfunction of milking machines, and poor milking techniques. Milking machines may damage the teat, allowing pathogens to enter the gland through the teat canal, and may transfer pathogens from one cow to another via contaminated equipment (Du Preez & Giesecke, 1994; Matthewman, 1999).

According to Raza (2004) the losses caused to the dairy industry by mastitis disease are enormous. Almost every herd suffers intermittent losses from good cows going 'light' of going blind in various quarters. The aggregate loss to the industry is one of the major deductions from economic production. It is probable that in some herds more than 15% of cows are rejected each year because of mastitis. Some cases of mastitis are caused by 'Streptococci' of human origin the type that produce septic sore throat and scarlet fever. These are a danger to the consumers of milk but are fortunately rare. The National Mastitis Council (USA) shows that, when bulk tank SCC is 200.000 cells/ml, about 6% of quarters in the herd could be expected to be infected. At 500.000 cells/ml 16% of quarters are likely to be infected with a 6% reduction in milk production. Thus, mastitis causes heavy losses in terms of costs or rearing cattle and heavy losses follow from early disposal before they have reached their maximal reduction (Raza, 2004).

Mastitis can be divided into two types, namely clinical and sub-clinical. Clinical cases are those with obvious signs such as a swollen, sore and red udder, as well as those with no other signs except changes in the milk such as the

presence of blood or pus, discolouration, or minute flecks visible only if a strip cup is used (Bremner, 1991). The sub-clinical cases show no obvious signs at all, but the inflammation exists all the same. Microscopic examination of the milk will reveal an increase in the number of inflammatory cells (somatic cell count) and a decrease in the volume of milk produced. If bacteria are involved, they can usually be cultured from the milk in the laboratory, and other properties of the milk such as the electric conductivity and the pH will also change. In all cases of mastitis, whether clinical or sub-clinical, there will be a decrease in milk production (Du Preez, 2000). However, sub-clinical mastitis (SCM), which is only detectable on the basis of changes in the composition of apparently normal milk, is a common and economically significant problem in dairy herds. A normal quarter is one that shows no outward signs of disease and which produces milk free from pathogenic organisms and with a SCC of less than 200,000 cells/ml (Du Preez & Giesecke, 1994).

The principal mastitis causing micro-organisms are bacteria, followed by viruses, yeasts and fungi (Du Preez, 1994). More than 80 different mastitis-causing bacteria species are known. Of all food-producing animals, dairy cows develop mastitis most often, but it also occurs less commonly in goats, sheep and pigs. Over the past century dairy cows have been bred for high milk production, with the calf only needing a small percentage of the milk produced for survival and growth and the cow's owner using the rest for sale at a profit. The udder of a high-yielding cow is subjected to enormous stress during the lactation period. This stress is harmful to the udder and to the cow's defence mechanism, rendering the animal more susceptible to mastitis than cows producing only enough milk to feed their calves (Du Preez, 1994).

According to Stewart (1995) management is the Achilles' heel of successful dairying. As a result of the diversity of skills required, successful dairying places a greater demand on management than does any other farming enterprise. Williams (1994) states that a dairy enterprise is one of the most complicated farming enterprises and it would be difficult for illiterate farmers to conduct such an enterprise. Management is a farmers' understanding of what to do and when to do it. Sanitation, ventilation, feeding, prevention and treatment of diseases,

close observation, and the provision of adequate space, water, feed, rest and exercise are all important management practices (Stewart, 1995).

Management plays a major role in the level of mastitis, which is evident on many dairy farms. Higher levels of mastitis usually occur on farms with a low level of sanitation, suboptimal teat dip application, inadequate dry cow antibiotic procedures, poor milking techniques, or inadequate machine maintenance (Costello, 1998). Dairy producers who utilise good mastitis control practices on a continual basis usually have a low level of mastitis on the farm. However, even on the best-managed farms, there are times when mastitis flare-ups occur. A herd's or cow's susceptibility to mastitis may be heightened by stressful conditions such as overcrowding, calving, early lactation, periods of high environmental temperatures and humidity, and periods of heavy rainfall (Costello, 1998).

According to Giesecke *et al*. (1994) a dairy farming operation cannot focus only on fatal diseases and other clinical animal health problems. The control of erosion diseases, i.e. diseases that are present mainly in sub-clinical forms and which erode animal health, reproduction, production and profits at hidden levels, is also essential. One of the most important erosion diseases in a dairy farm is mastitis, which is, of course, only one of many problems affecting the productivity of a dairy herd. It is a safe assumption that mastitis particularly sub-clinical is generally the single most underestimated disease affecting dairy cattle. Giesecke *et al*. (1994) also stated that the research conducted thus far had revealed that mastitis is the most costly disease in dairy herds in the absence of adequate measures for its control and prevention.

The intensification in modern dairy farming results in a significant increase in the bacterial load to which the cows are exposed, leading to a higher incidence of mastitis in modern dairy cows. The most common route followed by pathogenic bacteria to reach the udder tissue and cause infection is through the teat canal (galactogenic route). Other less important routes are via the bloodstream (haemotogenic route) and through injuries (traumatogenic route) to the teats or udder, which provide entry to the bacteria. Occasionally teat injuries do not allow

bacteria direct entry into the udder tissue, but the lesion provides an ideal environment for bacterial growth from where the bacteria can then gain entry through the teat canal into the udder tissue. A normal, healthy, intact and undamaged teat+ canal is the most important barrier that prevents or limits the penetration of pathogenic micro-organisms into the udder tissue. A high incidence of teat canal infections indicates a high bacterial load in the cow's environment. Herds in which the cows have a high incidence of teat canal infections also have a higher incidence of SCM (Du Preez, 1994).

Mastitis bacteria are spread from cow to cow at milking time by whatever touches the udder and teats – the hands, udder cloths and teat cups (Billet, 1995). Improving the udder health of dairy herds is highly necessary in South Africa, as the occurrence of clinical and sub-clinical mastitis is unacceptably high from economic, public health and other standpoints. The need to address the mastitis problem is more urgent in South Africa than in developed countries because of the prevailing economic conditions, market developments, population growth, and shortages of milk (Giesecke *et al*., 1994). Few countries have reliable information on the proportion of cows with udders infected by the various major mastitis pathogens (Swartz *et al*., 1984).

1.2 THE HYPOTHESES OF THE STUDY

The two hypotheses associated with the objectives of the study are the following:

1. The inadequacy of management skills in respect of dairy cows in the QwaQwa area has a detrimental effect on the incidence of mastitis in dairy cattle.
2. The incidence of mastitis is relatively high in dairy systems, and farmers have limited knowledge of this disease.

1.3 THE OBJECTIVES OF THE STUDY

1. To study the level of the mastitis problem, as well as farmers' knowledge when it comes to mastitis control on small-scale dairy farms in QwaQwa.
2. To investigate factors affecting individual cow somatic cell count (SCC), milk components and certain management and animal-related factors in the milk of dairy cows in QwaQwa.
3. To compare the California mastitis test (CMT) with the SCC methods for detecting sub-mastitis in dairy cows under QwaQwa farming conditions.
4. To assess the relationship between SCC and milk composition.

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CHAPTER 2

GENERAL LITERATURE REVIEW

2.1 INTRODUCTION

Mastitis, which is an inflammation of the mammary gland, can be caused by physical or chemical agents, but the majority of cases are infectious are caused by a variety of micro-organisms, mostly bacteria, which gain access to the interior of the mammary gland through the teat canal (Quinn *et al*., 1994). Initially, the small numbers of somatic cells those are normally present in the milk attempt to resolve this intra-mammary infection (IMI) immediately. Both bacteria and leukocytes in the infected quarters release chemical products, many of which are chemo-attractants for the leukocytes. In response, neutrophils move rapidly from the bloodstream into the milk in order to fight the infection. This constitutes the inflammatory response, which may go unnoticed in the form of SCM, or it may be severe enough to be classified as clinical mastitis (CM) (Suriyasathaporn *et al*., 2000). If the bacteria are contained or destroyed, the recruitment of neutrophils from blood into the mammary gland ceases and only a mild inflammatory episode will be required to restore health in the gland. Occasionally, the innate defence mechanisms of the infected mammary gland lose the battle with bacteria, which subsequently multiply out of control. This leads to a prolonged immune response within the mammary gland. Various cell types in the udder produce abundant soluble factors, such as cytokines, which eventually cause the clinical signs of mastitis characterised by physical, chemical, and usually bacteriological changes in the milk and by pathological changes in the mammary tissue (Suriyasathaporn *et al*., 2000). Hence, the udder inflammatory responses to IMI can result in an absence or a presence of clinical signs. Additionally, there may be clinical cases of mastitis in which no pathogens can be detected, usually defined as bacteriologically negative or aseptic mastitis (Radostits *et al*., 2000). Radostits *et al*. (2000) have classified clinical forms of mastitis according to severity and duration.

According to severity mastitis can be characterised as per acute when there is severe inflammation with swelling, heat and pain of the quarter, with a marked systemic reaction, which may be fatal. As acute when there is a severe inflammation without the marked systemic reaction. As sub-acute when there is mild inflammation with persistent abnormality of the milk, and as sub-clinical

when there is evidence of inflammation, e.g. high somatic cell counts (SCC's) in the milk without any visible abnormality of the milk or udder (Radostits *et al*., 2000).

According to duration mastitis can be characterised as short-term clinical or sub-clinical (as in coliform); recurrent clinical (as in *Staphylococcus aureus* and *Streptococcus dysgalactiae*); or as persistent clinical or sub-clinical (as in *Streptococcus agalactiae*). Clinical manifestations include abnormalities of secretion, size and consistency, as well as increased temperature of the mammary glands, and frequently a systemic involvement (Radostits *et al*., 2000).

2.2 ETIOLOGY

2.2.1 Mastitis-causing pathogens

Reports indicate that approximately 137 microbes are incriminated as etiological agents of mastitis and have been isolated from bovine udders (Watts, 1988). The most common isolates from bovine and other mastitis milk are *Staph. aureus*, Streptococci, and members of the Enterobacteriaceae (Quinn *et al*., 1994). The pathogens have been classified etiologically into two groups, namely contagious pathogens and environmental pathogens, depending on their distinct characteristics of distribution and interaction with the teat and teat duct (Calvinho *et al*., 1998). Within the two groups, there are two other subdivisions of major pathogens and minor pathogens.

2.2.1.1 Major pathogens

Major pathogens mostly cause CM. Under major mastitis pathogens there are two groups, namely contagious pathogens and environmental pathogens. The contagious pathogens include *Strep. agalactiae*, *Staph. aureus*, and *Mycoplasma bovis*. Contagious mastitis pathogens live and multiply in the cow's mammary gland and are spread from animal to animal primarily during milking (Calvinho *et al*., 1998). Infections due to contagious major pathogens tend to be chronic and sub-clinical but with periodic clinical episodes (Fox & Gay, 1993). The

environmental pathogens classified as major agents consist of environmental *Streptococci, Coliforms* and *Enterococci.* The environmental pathogens are those whose primary reservoir is the environment where cows live and not the infected mammary gland (Smith & Hogan, 1993). Although new infections by environmental pathogens can occur at milking, primary exposure appears to be between milkings. Other environmental pathogens reported in this subgroup include *Proteus, Yeasts*, *Prototheca* species and *Nocardia* species, which are opportunistic in nature (Watts, 1988). Individual cases or sporadic outbreaks of mastitis may be caused by *Pseudomonas* species, *Arcanobacter pyogenes*, *Serratia* species, or other unusual pathogens (Radostits *et al*., 2000). About 60-70% of environmental pathogen infections persist for fewer than 30 days. Mastitis caused by the major pathogens results in the greatest compositional changes to milk, including increases in SCC's, and has the most economic impact of all causative organisms (Radostits *et al*., 2000).

2.2.1.2 Minor pathogens

Infections by minor pathogens cause only moderate inflammation, with SCC's exceeding those of uninfected glands by only two to three-fold. Marked compositional changes in milk or dramatic decreases in milk yield occur following udder infection by minor pathogens (Radostits *et al*., 2000). The agents simply colonise the teat streak canal, but do not cause a clinical disease. Minor pathogens are also classified as contagious and environmental. Coagulase-negative staphylococci (CNS), consisting of a variety of *Staphylococcus* species, and *Corynebacterium bovis,* are contagious pathogens (Harmon & Langlois, 1986; Radostits *et al*., 2000). Minor pathogens are responsible for a high SCC, but at the same time improve the udder's resistance to invasion by the major pathogens (Rainard & Poutrel, 1988; Nickerson & Boddie, 1994). This is due to elevated SCC or an anti-microbial-like substance secreted by CNS that inhibits growth of *Staph. aureus*. There is also evidence of secretion of a factor that is inhibitory to growth and haemolytic patterns of *Staph. aureus*. However, quarters infected by CNS and *C. bovis* are susceptible to *Strep. agalactiae* (Nickerson & Boddie, 1994).

2.3 EPIDEMIOLOGY

2.3.1 General

Mastitis is a worldwide problem that affects dairy cows and lactating ewes, does, sows/gilts, queens, mares and bitches, as well as the females of wild ruminants and camels (Philpot, 1984). Mastitis is a multifactor disease that results when management and environmental factors interact to increase exposure reduce udder resistance, and aid deposition of organisms into the teat canal (Philpot, 1984). However, many researchers on the disease complex have only restricted the disease causation to microbial infection, ignoring the other important epidemiological players like environmental and managerial factors (Radostits *et al*., 1994). Most studies and surveys conducted worldwide have concentrated on the determinants (etiology) of disease rather than the effects of disease as determinants of production (Mungube, 2001). In the case of mastitis, both are important. Mastitis is extremely difficult to eradicate, but its control is feasible, cost-effective and practical and can greatly reduce associated economic losses (Radostits & Blood, 1985). Control measures such as paying special attention to milking technique and housing, avoiding teat injury, disinfecting teats before and after milking, and treating cows with antibiotics during dry periods have been reported to greatly reduce the occurrence of mastitis (Radostits *et al*., 2000). In most countries, surveys in dairy herds show that the prevalence of infection (mastitis) is approximately 50% in cows, with a quarter infection rate of about 25% (Radostits *et al*., 2000). The average annual incidence rate of mastitis, calculated as the number of quarters clinically affected per 100 cows at risk per year, including the dry period in individual herds, is 10-12% in most herds, but higher values ranging from 16-65% occur in some herds (Bartlett *et al*., 1992). The greatest risk of acquiring CM occurs early in lactation, usually in the first 50 days (Bartlett *et al*., 1992). Case fatality rates vary widely depending on the identity of the causative agent; for example *Strep. agalactiae* mastitis is not a fatal disease, but per acute staphylococcal mastitis in a recently calved cow may be fatal (Radostits *et al*., 2000).

2.4 RISK FACTORS ASSOCIATED WITH MASTITIS

2.4.1 Animal (host) risk factors

2.4.1.1 Age and stage of lactation

The prevalence of infected quarters increases with age, peaking at 7 years (Schukken *et al*., 1989). Older cows, especially after four lactations are more susceptible to mastitis (Quinn *et al*., 1994). It is postulated that young animals have diminished susceptibility due to a more effective host defence mechanism (Dulin *et* al., 1988).

Most new infections occur, especially with environmental pathogens, occur during the early part of the dry period and in the first two months of lactation (Smith & Hogan, 1993). Schukken *et al*., (1990) reported that the first month of lactation is the most sensitive period for mastitis risk in the cow, even in well-managed herds. This is due to increased stress as a result of depressed immunity due to metabolic changes and peak milk production during the early days following parturition. Prevalence of SCM increases as the stage of lactation progresses (Radostits *et al*., 1994). Other less important risk factors include other concurrent diseases, previous mastitis history, and pre-existing IMI's.

2.4.1.2 Presence of lesions on the teats

Lesions present on the teats may predispose the cow to inadequate milking and may harbour mastitis-producing bacteria and consequently increase the risk of infection (Quinn *et al*., 1994).

2.4.1.3 Nutritional status

Nutritional programmes associated with imbalances in anion-to-cation in the dry cow diet predispose the cow to periparturient hypocalcaemia, which in turn raises the risk of IMI (Radostits *et al*., 1994). Vitamins A and E and selenium may be involved in the resistance to certain types of mastitis (Erskine *et al*., 1987). Early

studies found that supplementation with antioxidants such as selenium and vitamins A and E had a beneficial effect on udder health in dairy cattle by reducing the incidence of CM (Radostits *et al*., 2000).

2.4.1.4 Prevalence of infection

The greater the prevalence of mastitis in the herd, the higher the new infection incidence and the longer the duration of infection. This is a major feature in herds with high levels of contagious pathogens and for which no strict hygiene measures are observed, since the infection spreads during milking (Calvinho *et al*., 1998). Environmental pathogens, on the other hand, may be a major problem in herds with successfully controlled contagious pathogens if the housing conditions and associated characteristics like bedding are of low hygienic standard (Smith & Hogan, 1993).

2.4.1.5 Low somatic cell count

Since leukocytes in the udder are present to resolve the IMI, once an intra-mammary challenge occurs, a very low SCC may predispose cows to a higher risk of CM, especially in high-yielding cows (Schukken *et al*., 1990). In an experimental study, it was demonstrated that factors such as low peripheral leukocyte count and low SCC are associated with a more severe mastitis response (Mungube, 2001).

2.4.1.6 Body condition score (BCS)

It has been demonstrated that cows with a low BCS (1 to 2) are at higher risk of contracting CM than cows with a BCS of 3 to 4. Body condition score is a tool for estimating energy balance status. Cows with a negative energy balance from feed restriction display a greater severity of experimental *Escherichia coli* mastitis (Suriyasathaporn *et al*., 2000). Cows with a low BCS are more likely to be ketotic. In an experimental demonstration, it was shown that ketone bodies diminished the chemotactic function of the leukocytes (Suriyasathaporn *et al*., 2000) and therefore may put a cow at risk for severe CM.

2.4.2 Environmental and managerial risk factors

In their study, Barkema *et al*., (1999) defined the farmer's management style as a specific combination of objectives, motivations and factors related to the production environment, such as quota and milk pricing system. Management style influences the specific organisation of different tasks in the labour process, as well as the coordination of, and the interdependency among, these different tasks (Van der Ploeg, 1996).

2.4.2.1 Management practices associated with the incidence rate of clinical mastitis (IRCM)

Risk indicators for the incidence rate of clinical mastitis (IRCM) can be categorised into three groups of factors: 1) resistance of the cow to IMI's; 2) exposure to pathogens; and 3) cure of IMI or inflammation. Management practices and risk indicators that are associated with IRCM and which are reported to be related to IMI resistance are nutrition (Erskine, 1986; Schukken *et al*., 1990), milk production, leaking of milk, breed of cow, and post-milking teat disinfection – PMTD. Management practices and risk indicators that are associated with IRCM and which are reported to be related to exposure to pathogens are housing, hygienic condition of cubicles and cows (Erskine, 1986), as well as milking procedures (Schukken *et al*., 1990). Finally, management practices and risk indicators that are associated with IRCM and which are reported to be related to the cure of existing IMI are dry cow therapy and treatment of cases of CM (Barkema *et al*., 1999). The milking machine also influences the IRCM via resistance to both IMI and the transmission of pathogens (Barkema *et al*., 1999).

2.4.2.2 Management practices associated with low, medium, and high somatic cell count in bulk milk

In a study conducted by Barkema *et al*., (1998) it was found that PMTD and dry cow therapy were practised most frequently in herds with a low bulk milk somatic cell count (BMSCC). In herds with a low BMSCC, more attention was paid to

hygiene and detail than in herds with a medium or high BMSCC. Seventy-three percent of the herds with a high BMSCC were managed by farmers whose management style was classified as quick and dirty, compared with 74% of the herds with a low BMSCC managed by farmers whose management style was classified as clean and accurate (Barkema *et al*., 1999). Cubicles, drinking buckets and cows were cleaner in herds with a low BMSCC, and the management practices for these herds more often included the yearly clipping of the hair of all cows. Cleaner calving pens and cubicles in herds with a low BMSCC coincide with the results of Hutton *et al*., (1990), who also reported that the moisture level of the bedding for lactating cows and in maternity pens was lower in herds with a low BMSCC. Overall better hygiene reduces exposure to environmental pathogens in cubicles and calving parlours and diminishes the transmission of contagious pathogens during milking. Barkema *et al*. (1999) concluded that management style did have an influence on the implementation of measures to prevent mastitis, because farmers with a clean and accurate management style implemented measures such as PMTD and antibiotic dry cow therapy more often and for longer periods than farmers with a management style considered to be quick and dirty.

2.4.2.3 Quality and management of housing

The quality and management of housing for dairy cattle has a major influence on the types of mastitis pathogens that can infect the mammary gland and the degree of infection pressure (Radostits *et al*., 2000). The management and design of a housing system influences the prevalence of IMI and the incidence of CM. Any housing factor or management system that allows cows to become dirty or damage their teats or which causes overcrowding will result in an increase in CM (Radostits *et al*., 2000). Ventilation is a critical factor in the maintenance of dry conditions. Very old structures frequently have extremely poor ventilation, which is a major risk factor for mastitis (Smith & Hogan, 1993). A design that features free stalls built against outside walls or any solid wall should be avoided as a risk factor in the incidence of mastitis (Smith & Hogan, 1993). A design that does not permit the free movement of urine and other waste products allows the accumulation of such waste products, which harbour an assortment of pathogens

mostly of the environmental type, serving as a reservoir for IMI. The type of bedding also has a major influence on the mastitis infection rate. Sand and other inorganic materials have low moisture content and contain fewer nutrients that can be utilised by bacteria – in contrast to organic materials like straw, sawdust, recycled manure and paper (Smith & Hogan, 1993). The majority of the bacteria in organic bedding are environmental bacteria; for example straw tends to have the highest streptococcal counts, while sawdust and recycled manure have the highest coliform counts amongst organic bedding materials (Smith & Hogan, 1993).

2.4.2.4 Herd size

The size of the milking herd may be positively associated with an increased incidence of CM, because it is more difficult to control contagious mastitis in a herd with a greater prevalence of infection and a larger number of cow-to-cow contacts. As a herd grows in number, so manure disposal and sanitation problems increase the exposure to environmental pathogens (Bartlett *et al*., 1992).

2.4.2.5 Milking practices

Contamination of the udder immediately before and after milking is a significant risk factor for mastitis (Peeler *et al*., 2000). Milking presents an opportunity for any pathogen present on the udder to penetrate the teat canal. Confinement in the yard after milking is recommended for 20-30 minutes, as it encourages cows to remain standing while the teat ducts are still open and thus more vulnerable to penetration by mastitis pathogens present elsewhere (Blowey & Edmondson, 2000). Udder preparation both before and after milking influences the rate of mastitis infection in a given herd. It has been established that farmers who use a common cloth/sponge for drying teats after cleaning the udder put their herds at greater risk of a high prevalence of infection than farmers who use individual paper towels (Dargent-Molina *et al*., 1988). Wet teats and udders are a risk factor for increased SCC (Radostits *et al*., 2000). Water is a helpful necessity for the effective cleaning of dirty teats and udders, but at the same time it can also carry

bacteria down the teat from a wet udder and thus contaminate milk during milking (Bushnell, 1984). A drying-off procedure at the end of a lactation period and an active drying-off treatment policy is very important in reducing the level of IMI, especially with Coliforms (Thirapatsakun, 1989).

A higher number of person-hours spent milking each cow is said to be associated with a higher rate of CM (Bartlett *et al*., 1992). Failure to change the teat liners of milking machines after every 2500 milkings constitutes a serious risk factor in the incidence of mastitis (Peeler *et al*., 2000). Further investigation is required to clarify the importance of milking machine management. Pre-milking teat dipping helps reduce environmental mastitis by as much as 50% in some herds, although this reduction is not observed in all herds. Failure by pre-dipping to control environmental mastitis in all herds likely reflects the complex epidemiology of environmental pathogens (Smith & Hogan, 1993). The stripping of foremilk prior to cluster attachment in those farms that practise machine milking and also prior to hand milking has been shown to be a risk factor in the incidence of mastitis, especially of the contagious type (*Staph. aureus* mastitis). Foremilking could expose other at-risk cows to mastitis pathogens in the stripped milk, in the same way as leaked milk, or through increased contamination of the cow's teats from the dairyman's hands.

2.4.2.6 Climatic influences

The incidence of mastitis, especially in the tropics, is associated with the prevalence of rain. The time spent by the cow out in the sun protects it against environmental mastitis due to the cleansing effect of the sun's radiation, and also due to a reduction in the cow's period of exposure to micro-organisms contained in the bedding (Smith *et al*., 1985; Schukken *et al*., 1989).

2.4.2.7 Feeding after milking

Feeding a cow after it has been milked is necessary to ensure that the cow remains standing (while feeding and does not lay on the soil/bedding while the sphincter is still open). In a study conducted by Barkema *et al.* (1999) it was

found that farmers whose management styles were clean and accurate were stricter about hygiene and prevented their cows from lying down in the cubicles shortly after milking, in contrast to farmers whose management styles were quick and dirty. A cow that lies down immediately after milking can be at risk of infection, since the teats are still open. In the case of a cow that remains standing, the teats are given time to revert to their normal anatomical shape, thereby reducing the risk of acquiring environmental pathogens (Radostits *et al*., 2000; Peeler *et al*., 2000).

2.4.2.8 Traumatic influences

External trauma such as that arising from rough treatment is most frequently inflicted on cows as they are driven into the milking parlour and could be a risk factor in the incidence of mastitis. This could be as a result of animals suffering bruises to the teats or running through muddy and unhygienic stretches in the rush to the milking shed, thereby predisposing them to environmental pathogens (Quinn *et al*., 1994).

2.5 FACTORS AFFECTING MILK SOMATIC CELL COUNT (SCC) AT INDIVIDUAL COW LEVEL

The SCC is commonly a combination of leukocytes and epithelial cells used as a measure of milk quality. Somatic cells are simply animal body cells present at low levels in normal milk. High levels of these cells in milk are an indication of abnormal, reduced-quality milk caused by an intra-mammary bacterial infection (mastitis) (Rice & Bodman, 2004).

The SCC is influenced by stage of lactation, number of lactations, age of the cow, breed, feeding, type of housing, seasonal variations, geographic region, and stress. The most significant factor raising the level of SCC in milk is udder infection (mastitis), which in most instances develops into a local inflammation of the udder tissue and develops without any symptoms or visible changes in the milk (SCM) (Kalit & Lukac, 1998).

The following factors affecting the milk SCC at individual cow level have been identified: mastitis, infection status, cow age, parity and stage of lactation, stress and seasonal effects, milking frequency, breed, udder irritation and injury, indirect causes, diurnal variation, and day-to-day variation.

2.5.1 Mastitis

Mastitis is by far the most important factor that causes increased cell counts (Blowey & Edmondson, 2000). The normal SCC of quarter milk is generally below 200 000 cells/ml in cows; 100 000 cells/ml in heifers. A quarter-milk SCC of more than 300 000 cells/ml is considered abnormal (Loubser *et al*., 2001). When mastitis causing organisms enter the udder, the defence mechanisms send vast numbers of white blood cells into the milk in an attempt to kill the bacteria. If the infection is eliminated, the cell count returns to its normal level, but if the white cells are unable to remove the organisms, a sub-clinical infection is established and a high SCC recorded in the milk of the affected quarter/s (Blowey & Edmondson, 2000).

2.5.2 Infection status

The major factor affecting SCC at the experimental cow's quarters or bulk-tank levels is an infection of the mammary gland (Dohoo & Meek, 1982; Schepers *et al*., 1997). With respect to the cow's quarters, SCC from normal (i.e. uninfected) quarters are generally below 200 000, but may be below 100 000 during the first lactations of cows (Harmon, 1994) or in well-managed herds (Rice & Bodman, 2004). One study estimates that 50% of uninfected cows have SCC below 100 000 per ml, with 80% having less than 200 000 (Eberhart *et al*., 1979). A higher SCC is abnormal and an indication of inflammation in the udder. The major pathogens that cause the greatest SCC increase include *Staph. aureus*, *Strep. agalactiae*, Coliforms and *Streptococcus* species other than *Strep*. *agalactiae* (Eberhart *et al*., 1979; Sheldrake *et al*., 1983). Minor pathogens (*C. bovis* and CNS) usually cause only a moderate increase in SCC over that of uninfected quarters (Harmon, 1994).

2.5.3 Cow age, parity, and stage of lactation

Generally SCC increases with advancing age and stage of lactation (Harmon, 1994). However, work by Eberhart *et al*. (1979) showed that if cows are separated into groups by infection status, little change in SCC occurs for uninfected cows, either as they age or progress in lactation. Sheldrake *et al*. (1983) confirmed the finding that milk from uninfected quarters displays little change in SCC with increasing numbers of lactation or with advancing stages of lactation. According to Horner & Randles (1995) a cow in her first lactation should have SCC of less than 100 000 per ml. Older cows should have a cell count of less than 250 000 per ml, but it may be as high as 500 000 per ml.

Elevated SCC may occur in milk in late gestation and for a few weeks following calving, regardless of infection status. This SCC elevation appears to be part of a cow's natural immune system response in preparation for calving, in order to enhance the mammary gland defence mechanisms at this critical parturition time. Quarters with no infection generally show a rapid decline in SCC within a few weeks postpartum (Rice & Bodman, 2004).

The major influence of parity and stage of lactation on SCC is related to IMI status. The SCC in colostrums is very high after calving, and in healthy cows usually decreases within four to 10 days to about 100 000 to 200 000 cells/ml of milk. The SCC usually increases only after the milk production of the cow falls to less than four kilograms of milk per day (Du Preez, 2000b).

2.5.4 Stress and seasonal effects

Stresses of various types have been implicated as causing increases in SCC (Dohoo & Meek, 1982; Rice & Bodman, 2004). An extremely interesting study in France evaluated the effect of exercise on SCC in milk from infected and uninfected cows (Coulon *et al*., 1998). Cows were either housed in a barn or were subjected to walking 9.6 kilometres after each morning milking for 23 days. The SCC of the milk from uninfected cows that walked each day increased by 47 000 cells/ml (above that of cows at rest) compared with an increase of 185 000

cells/ml in the SCC of milk from infected cows that were made to walk. Walking also resulted in reduced milk production and lower forage intake. The authors concluded that a combination of infected udders and traumatic inflammation induced by extreme exercise had a marked and potentially economic influence on SCC level. This could suggest that stresses of various types may further aggravate the inflammation in infected cows while having little effect on SCC in uninfected cows. Smith *et al*. (1985) suggest that the stress of high temperatures and humidity might increase the susceptibility to infection, as well as the number of pathogens to which cows are exposed. Additional data support the association between the rates clinical mastitis with bacterial counts in bedding (Hogan *et al*., 1989). These findings support the concept that temperature stress *per se* is not the cause of increased SCC, but increased SCC is a result of greater exposure of teat ends to pathogens resulting in more new infections and clinical cases during the summer months (Hogan *et al*., 1989).

Somatic cell count levels are usually lowest in a clean, dry, comfortable environment. Weather and management factors play an important role in relation to the control of mastitis. Somatic cell counts are generally lower during the winter and higher during the summer (Dohoo & Meek, 1982; Wells & Ott, 1998). This coincides with an increased incidence of CM in the summer months, which has been reported in several studies (Paape *et al*., 1973; Smith *et al*., 1985; Hogan *et al*., 1989). Smith *et al*. (1985) have shown that the rate of infection with environmental pathogens is highest during the summer and coincides with the higher number of Coliforms in bedding material.

2.5.5 Milking frequency

Many farmers reduce the frequency of milking to once daily or even every other day before drying off. Research shows that cows milked intermittently towards the end of lactation have dramatically increased cell counts (Blowey & Edmondson, 2000). Blowey & Edmondson (2000) report that the average cell count of non-infected cows yielding over 5 litres of milk per day is 237 000, but when these cows were not milked for two days the cell count rose to 540 000.

2.5.6 Breed

Breed is one of the factors affecting milk constituents. Belcher *et al*., (1979) found no significant differences for milk fat percentage, but milk protein percentages had differences between breeds. Sharaby (1998) found breed differences for fat, protein and lactose content in milk in Jersey and Holstein cows.

There is a slight difference in the SCCs of the normal milk of different breeds of cows. The Ayrshire breed has a slightly lower SCC than the Friesian breed. It is possible, to a limited extent, to breed cows with a relatively low SCC (Du Preez, 2000a).

2.5.7 Udder irritation and injury

The most important cause of udder irritation in South Africa is faulty milking equipment due to poor installation or maintenance or the incorrect use thereof. Hard surfaces in sleeping areas or rough handling of udders could also irritate the udders. Udder irritation leads to deterioration of the teat canal (the main defence mechanism of the udder) and may be followed by mastitis (Loubser *et al*., 2001).

Tissue damage from injury in the individual cow may temporarily elevate SCC even without infection. Such instances would usually be of short duration and improve as healing occurs. Damaged tissue is quite susceptible to infection, and therefore it is important to prevent injury by eliminating ledges, debris, slick floors, etc. (Rice & Bodman, 2004).

2.5.8 Indirect causes

Poor milking procedures contribute heavily to the rate of new infection due to transmission of the disease at milking time. The result is an elevated SCC. Faulty milking equipment due to poor installation or maintenance can cause tissue trauma, teat damage, poor milk-out, erratic vacuum levels, etc. and can also transmit infectious agents at milking time (Rice & Bodman, 2004).

2.5.9 Diurnal variation

A normal (diurnal) variation in SCC occurs with the fraction of milk collected throughout a milking, and diurnal variation occurs during the time between milkings (Dohoo & Meek, 1982). With two milkings per day, cell counts tend to be higher with the afternoon milking than the morning milking. This is partly due to a briefer milking interval and lower milk yield resulting in a concentration effect (Blowey & Edmondson, 2000). Harmon (1994) reports that SCC is higher in the stripping and the lowest immediately before milking. The elevated SCC may persist for up to 4 hours after milking and then gradually decline. This difference in high and low SCC in stripping versus foremilk at milking time may vary from four- to seventy-fold in individual quarters (White & Rattray, 1965).

2.5.10 Day-to-day variation

In dairy cattle it has been reported that the cell counts of cows also vary from day to day by up to 25% of the baseline count. The variation is small in uninfected cows, but may be much larger in cows with active infections (Kirk, 1984).

It has been reported that fluctuations in individual quarter samples from uninfected cows run in parallel, suggesting physiological factors acting at the cow level (Dohoo & Meek, 1982). Donovan *et al*., (1992) mention that day-to-day variations in milk SCC could be due to other factors affecting SCC such as age, stage of lactation, environmental temperature, and stress.

2.6 MILK COMPOSITION

Milk is a biological fluid with many different constituents (Kennelly, 1996). The grading standards for different types of milk in South African cows are shown in Table 2.1 (Agricultural Products Standards Act, 1990). Milk fat content is highest in high-fat milk and lowest in fat-free milk. Solids non-fat (SNF) content is lowest in high-fat milk and highest in fat-free milk. The protein content is 3.0% in high-fat, full-fat, low-fat and fat-free milk.

TABLE 2.1: Standard grading of different types of milk in South Africa

Milk	Milk fat content	Minimum solids not-fat content	Protein content
High-fat milk	≥ 4.5	8.2	≥ 3.0
Full-fat milk	≥ 3.3	8.3	≥ 3.0
Low-fat milk	1.5-2.5	8.4	≥ 3.0
Fat-free milk	≤ 0.5	8.6	≥ 3.0

(Source: Agricultural Products Standards Act, 1990)

The consumer demand for safe, high-quality milk has placed a significant responsibility on dairy producers, retailers and manufactures to produce and market safe milk and milk products. The first step in the production of quality milk begins at the dairy farm, and therefore the responsibility lies with the dairy producer to produce raw milk under the strictest hygienic standards. All dairy producers recognise the fact that the production of quality milk and a reduced incidence of mastitis would result in improved returns on the milk produced. However, the task of producing quality milk and maintaining cows with a low incidence of mastitis is a management challenge for all dairy producers. As dairy farming becomes more complex and intense, the need to provide dairy producers with assistance when it comes to milk quality and mastitis through the transition process is critical (Jayarao *et al*., 2003).

Jayarao *et al*., (2003) stated that good-quality raw milk with low bacterial and SCC's yield high-quality milk and milk products with a longer shelf life. Good farm management practices such as mastitis prevention, proper udder preparation before milking, and proper maintenance and cleaning of the milking system have all been shown to lower somatic cell and bacterial counts in raw bulk tank milk. Good-quality milk production is one of the main objectives in dairy farming, on either larger or small-scale farms, since milk of good quality is desirable and hence saleable to the processors and acceptable by the consumers (Thirapatsakun, 1989).

2.6.1 Factors affecting milk composition

Mastitis is also responsible for changes in milk composition. These changes result firstly from a reduction in synthesis activity for the main components of milk (i.e. fat, lactose and casein), and secondly from an increase in the presence of blood elements due to inflammatory reaction, for example proteins (serum albumin and immunoglobulin), chloride, and sodium (Larson *et al*.,1980). However, current milk-pricing systems rely mostly on total-fat and total-protein yields (or percentages) and on the lipolysis index of the delivered milk (Hortet & Seegers, 1998).

The current interest in the nutrient composition of milk is due to the nutritional importance of milk in the human diet. However, the composition of milk is not absolute, as many factors influence the end product. There are several factors that are non-nutritional and which can have an effect on the constituents of milk, namely: Genetics and environment, stage of lactation, mastitis, season, age of the cow, and variations during milking (Hurley, 1987).

2.6.1.1 Genetics and environment

A change in milk composition through traditional breeding techniques occurs slowly, although new techniques of genetic manipulation may allow more rapid progress in future (Waldner *et al*., 2004). The composition of milk differs within species, especially in dairy cows. The lactose content of milk is fairly constant amongst breeds, while protein varies to some extent, but milk fat varies extensively (Waldner *et al*., 2004). The high-yielding breeds produce milk with a lower content of both fat and protein. The average protein content of milk of Holstein-Friesland and Ayrshire cows varies between approximately 3.3 and 3.5% compared to 3.6 and 3.9% for Guernsey and Jersey cows. According to Neitz (1995) butterfat percentage is partly hereditary, which leads to a difference in average butterfat percentage amongst different breeds. It has been found that the milk of the Guernsey (5.0%) and Jersey (5.5%) breeds contains the highest amounts of milk fat, compared to Holstein milk (3.5%), which contains the lowest fat percentage (Hurley, 1997). Neitz (1995) also states that it is common for high-

production cows to produce milk with a low fat content, but the composition of milk of individual cows of a particular breed can differ greatly; for instance a poorly bred Jersey cow may produce milk with 3% fat, while a well-bred Holstein-Friesland cow may produce milk with a fat content of 4.3% (Neitz, 1995). Yields of fat, protein, SNF, and total solids are highly and positively correlated with milk yield (Waldner *et al*., 2004).

2.6.1.2 Stage of lactation

Composition of milk varies considerably during lactation, with the major changes usually occurring soon after the start of lactation (Hurley, 1987). Colostrums, the secretion obtained during the first few milking after calving, have high total solids content, which is mainly protein. The milk production of cows increases after calving, to reach a maximum (peak) level during the second month of lactation. It then decreases again gradually as the lactation progresses. The butterfat percentage decreases during the first three months of lactation, and then remains constant for three months. After this period of five to six months, a more noticeable increase occurs at the end of the lactation period. The protein diminishes during the first or second month of lactation, after which it gradually increases. The lowest protein values of milk are found during the late summer and early autumn, while the highest values occur during spring. Normally, an increase in milk yield is followed by a decrease in the percentages of milk fat and protein, while the yields of these constituents either remain unchanged or increase (Waldner *et al*., 2004).

2.6.1.3 Disease (mastitis) and somatic cell count (SCC)

Although other diseases can affect milk component content and distribution, mastitis has been the predominant disease studied (Neitz, 1995; Waldner *et al*., 2004) and is also responsible for changes in milk composition. Research has shown conclusively that elevated SCC (above 200 000 cells/ml) has a significant negative impact on the udder. Mastitis, the primary cause of increased SCC, causes injury to milk secretory cells in the mammary gland, which interferes with

the synthesis of lactose, fat, and protein (Schallibaum, 2001). It has been known for some time that a higher SCC causes a reduction in milk yield. Since milk yield is affected by mastitis, a decrease in milk production is considered to be the main factor in economic losses due to clinical and sub-clinical mastitis (Hortet & Seegers, 1998).

Table 2.2 lists examples of some changes in milk components that accompany mastitis (Harmon, 1994). Compositional changes accompany the elevation of SCC and inflammation in an infected mammary gland (Harmon, 1994). Mastitis or elevated SCC is associated with a decrease in lactose and fat in milk as a result of reduced synthetic activity of the mammary tissue. Fat yield decreases due to a decline in milk production, while protein content may undergo little change.

TABLE 2.2: Compositional changes in milk constituents associated with elevated somatic cell count (SCC)

Constituent	Normal milk	Milk with a high SCC	Percentage of Normal milk
*SNF	8.9	8.8	99
Fat	3.5	3.2	91
Lactose	4.9	4.4	90
Protein	3.61	3.56	99

*SNF = Solids non-fat (Source: Harmon, 1994)

Milk from cows with elevated SCC's (greater than 500 000 somatic cells/ml) has a longer coagulation time and forms weaker curds than milk from cows with lower SCC's (Waldner *et al*., 2004). Mastitis lowers both yield and SNF (Neitz, 1995). In dairy cattle, milk with a high cell count has lower fat and lactose levels than milk with a low cell count (Dohoo & Meek, 1982). Miller *et al*., (1983) reported a low percentage of lactose in milk with a high SCC, but high percentages of fat and protein. Roussel *et al*., (1969) found a significant positive correlation between milk fat and SCC in dairy cattle. However, Eicher *et al*., (1999) found that SCC did not influence protein in milk from dairy cows.

2.6.1.4 Season

Milk fat and protein percentages are the highest during autumn and winter and the lowest during spring and summer. This variation is related to changes in both the types of feed available and climatic conditions. Lush spring pastures, which are low in fibre, depress milk fat. Hot weather and high humidity reduce dry matter intake and increase feed sorting, resulting in lower forage and fibre intake (Waldner *et al*., 2004).

2.6.1.5 Age of the cow

The age of the cow is closely related to the number of lactations. An increase in the number of lactations is associated with a drop in the fat and SNF content of milk. Beyond the fifth lactation there is only a small change in fat and SNF (Neitz, 1995). The age of the animal is of little or no importance as the fat content of commercial mixed milk is concerned, as its affect is small and herds include cows of varying ages (Rook, 1961). While milk fat content remains relatively constant, milk protein content gradually diminishes with advancing age (Waldner *et al*., 2004).

2.6.1.6 Variations during milking

Even during milk removal or milking, the composition of milk can vary. Milk fat is lowest in the foremilk and gradually rises in percentage as the milk is removed. The fat content of the first milk extracted is 1.95% and that of the last milk is 10%. If a cow is not milked out fully, some of the fat remains behind and the fat content of the milk will be low. An inefficient milker unable to milk out a cow completely causes the milk flow to be retarded, and the butterfat is detrimentally affected (Neitz, 1995).

When the milking intervals are uneven, the cows give less milk after the shorter interval, but this milk has a higher fat content. Again, when cows are milked twice a day at regular intervals, there is little difference between the fat percentage and milk production of the different milking times, even if the milk yield of the morning

is a little higher with a slightly lower fat percentage. When cows are milked three or four times per day, the milk collected in the middle of the day contains a little more fat (Neitz, 1995).

2.6.2 Regulations relating to milk and dairy products in South Africa

From a human health perspective, South African government regulations stipulate the following regarding the quality of milk and dairy products, and these regulations force all dairy farmers to produce high-quality and hygienic milk for human consumption:

i. No person shall use or sell raw milk intended for further processing which contains the following: Antibiotics or other antimicrobial substances in amounts that exceed the maximum residue levels containing pathogenic organisms, any extraneous matter that gives a standard plate count of more than 200 000 colony-forming units (CFUs)/ml of milk, or, when subjected to the standard methods for counting somatic cells, is found to contain an average of 500 000 or more somatic cells/ml of bovine milk or an average of 750 000 or more cells/ml of goat's or sheep's milk (South Africa Government Notice of 2001).

ii. No person shall sell for consumption raw milk, raw cream or raw skimmed milk that gives a standard plate count of more than 50 000 CFUs per 1.0 ml of the milk when subjected to the standard plate count test (South Africa Government Notice of 2001).

iii. No person shall sell for consumption raw milk that has become sour which contains more than 50 Coliform bacteria/ml of milk, is not packed in a closed container and does not bear clearly the words "Unpasteurised sour milk" or "Ongepasteuriseerde suur melk" or "Raw sour milk" or "Rou suur melk" and no person shall sell a pasteurised milk that gives a standard plate count of more than 50 000 CFUs/ml of milk (South Africa Government Notice of 2001).

2.7 ECONOMIC LOSSES DUE TO MASTITIS

Mastitis, or inflammation of the mammary gland, is one of the most complex and costly diseases of the dairy industry. The widespread occurrence of the disease in dairy herds creates an essential loss to producers of approximately 2 billion dollars in the United States alone. This figure excludes the additional untold losses from altered milk quality and composition, and the effects on dairy products that occur once milk has left the farm (De Graves & Fetrow, 1993).

2.7.1 Diminished milk production

Significant losses in milk production from individual cows and herds have been shown to be associated with elevated SCC's – higher cell counts mean greater losses. The likelihood of losing an individual cow increases from 6% to 30% as the cell count rises from 100 000 to 1 600 000 cells/ml, while the likelihood of losing the entire herd increases from 6% to 29% as the cell count rises from 500 000 to 1 500 000 cells/ml (Mungube, 2001). De Graaf & Dwinger (1996) reported crude milk production losses per cow with SCM to be estimated at 1.56 kg per day. Milk production loss per affected quarter due to SCM was estimated to be 17.6% on average (De Graaf & Dwinger, 1996). De Graves & Fetrow (1993) report a loss in the range of 10% up to 26% per affected quarter with SCM. Radostits *et al*. (2000) estimate about the same (10-25%) loss in milk yield following infection with SCM. Dobbins (1977) estimates an absolute decrease in milk production per California mastitis test (CMT) score per quarter as follows: CMT score negative as 0 kg loss, Trace as 0.27 kg loss, 1 as 0.991 kg loss, 2 as 1.76 kg loss, and CMT score 3 as 2.61 kg loss in milk yield per quarter. Most estimates indicate that on average an affected quarter results in a 30% reduction in productivity, and an affected cow is estimated to lose 15% of its production for the lactation following infection with SCM (Radostits *et al*., 2000). Schepers & Dijkhuizen (1991) reported that 70% of total losses due to mastitis arise from diminished milk production. The loss in production by an affected quarter following SCM may be largely compensated by increased production in the other

quarters so that the net loss to the cow may be less than expected (Radostits *et al*., 2000). In cases of CM, milk yield drops substantially and losses are much greater in early lactation than late lactation (Radostits *et al*., 2000). Singh & Singh (1994) estimate a 50% reduction in the milk yield of a cow suffering from CM. Clinically affected quarters might not completely recover milk production in subsequent lactations, but the carry-over losses are not as great as the losses from acute mastitis (Radostits *et al*., 2000).

2.7.2 Losses due to culling

Culling due to mastitis becomes necessary when an IMI cannot be cured, often because the bacteria causing the disease fail to respond to commonly used antibiotics (resistance development). The proportion of culls due to mastitis is related to the bacteria infecting the udder. For example, when *Arkanobacter pyogenes* causes mastitis, a larger number (> 80%) of affected cows are likely to be culled than when mastitis is caused by other agents. Coliform and staphylococcal mastitis contribute substantially to a relatively higher proportion, since these agents cause peracute and gangrenous forms of mastitis (Dijkhuizen & Morris, 1997). Culling results in two types of losses, namely the reduced slaughter value of a cow, along with a higher replacement cost and loss of production time following premature removal from the herd before the animal in question attains its optimal production age (Singh & Singh, 1994; Radostits *et al*., 2000). Replacement costs following culling are estimated to contribute about 14% of the total mastitis losses (Schepers & Dijkhuizen, 1991).

In most developing countries, farmers do not cull animals suffering from mastitis because they are not aware of the economic losses arising from the presence of this disease in their herds. As a result of this existing ignorance among farmers, especially in most sub-Saharan African countries, the economic losses due to failure to cull chronically infected cows could be extremely high (Mungube, 2001). However, the information available on the losses related to mastitis disease is scanty, or at worst non-existent.

On organised dairy farms, particularly in industrialised nations, the carrier animals are culled if the mastitis problem continues or if the affected quarter goes blind. Many dairy managers will cull those chronically infected cows that fail to respond to therapy as the only option to clinically manage, and especially control, mastitis (Radostits *et al*., 2000).

2.7.3 Treatment costs

In Sub-Saharan Africa (SSA), Asia, and the majority of Latin American countries, mastitis therapy is mostly restricted to the clinical forms of the disease, with only a few elite farmers treating cows with SCM. For each case of CM in a herd population there will usually be 15 to 40 sub-clinical cases (Mungube, 2001). This point to the high losses suffered by farmers not able to recognise sub-clinical cases and institute therapeutic measures. Blosser (1979) asserts that most dairymen are not aware of the existence of SCM in their herds, as the symptoms are not visually evident to them. Hence, much of the treatment cost incurred on many farms is due to CM, with a negligible figure attributed to SCM. The failure to attend to both forms of the disease is due to a lack of proper diagnostic kits and skilled personnel, as well as limited funds available to purchase the necessary medications for the treatment of both sub-clinical and clinical mastitis.

Unlike industrialised countries where treatment costs constitute the cost of medications, veterinary charges, labour costs, and the withdrawal of milk for at least three days following treatment (Dobbins, 1977) the situation in SSA is different, since almost no farmers withdraw milk after treating mastitis-afflicted cows. A review of the economics of mastitis by Schepers & Dijkhuizen (1991) estimated that 8% of the total losses are due to medication costs and veterinary fees, with another 8% being due to discarded milk following treatment after a mandatory withdrawal period of 72 hours. Blowey (1986), unlike his fellow investigators in developed countries, asserts that instead of discarding milk following treatment for three days, the milk can be fed to calves and dogs, in the process avoiding the total loss (giving a salvage value). Apart from the milk discarded following antibiotic treatment of mastitis-afflicted cows, a number of unfavourable changes occur following mastitis, with a reduction in the hygiene

quality of the milk, which necessitates such milk being discarded for public health reasons (Thirapatsakun, 1989). Medication costs constitute the largest portion of treatment cost, as different commercial intra-mammary preparations are sold at the prevailing market prices. On average, intra-mammary infusions are administered at 12/24-hour intervals over three consecutive days. This means that the total cost of medications is equal to the cost of three treatments multiplied by the number of affected quarters/cows (Singh & Singh, 1994).

2.8 MASTITIS PREVENTION AND CONTROL MEASURES ON DAIRY FARMS

Control measures for mastitis include maintaining pre-milking udder hygiene, post-milking teat dipping, dry cow therapy with long-acting antibiotics, segregation and culling strategies for chronically infected animals, and environmental control during the dry cow and calving periods. Each of these control measures is aimed at the management of specific pathogen types; for example, pre-milking udder hygiene and teat dipping are aimed at preventing new infections, primarily caused by contagious pathogens, during the milking period. Dry cow therapy with long-acting antibiotics is used to cure sub-clinical infections present at the time of dry-off. Dry cow therapy is used with other management efforts to reduce the occurrence of new cases of environmental streptococcal infections during the early dry period. Environmental management during the transition and calving periods is targeted primarily at preventing new infections with environmental streptococcal species and Coliform bacteria (e.g. *Escherichia coli*, Klebsiella species) (Sargeant *et al*., 2001).

Several preventative measures have been considered in an attempt to control mastitis. The eradication of mastitis-causing pathogens was examined but dismissed as impractical due to the numerous pathogens associated with mastitis (Schutz, 1994). A more practical approach to controlling invading pathogens is through the application of sanitation practices, which reduces the quantity of bacteria and to date remains one of the most effective methods of controlling mastitis (Schutz, 1994). Methods of mastitis prevention include eradication,

sanitation, and genetic improvement, and vaccination, isolation of infected animals, antibiotic therapy, and culling. Sanitation practices, including proper cleaning and drying of udders prior to milking, well-maintained milking equipment, teat dipping after milking, and clean housing for cows, have proven to be the most effective means of mastitis prevention. Eradication would be the method of choice, but is not possible due to the numerous sources of mastitis infection, and the implausibility of eliminating all infectious pathogens. Vaccination against some mastitis-causing pathogens shows promise (Cranford, 1999) as a preventative measure, but efficacy rates remains low. Treatment of mastitis with antimicrobial therapies is effective for some pathogens, but costly in terms of increased labour and treatment costs, as well as milk having to be discarded due to the withholding of treated milk because of antibiotic residual restrictions in the milk. Culling eliminates mastitis, but additional costs are incurred for replacements (Cranford, 1999).

However, any mastitis control programme should have the following qualities for it to be successful: It must be cost effective, easily adaptable to the dairy management systems currently in use, lead to visible success by a rapid reduction in the number of clinical cases, as well as a steady improvement in the parameters used for monitoring udder health status, and it must be within the scope of the average dairy farmer's understanding (Radostits *et al*., 1994).

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CHAPTER 3

INCIDENCE OF CLINICAL MASTITIS AMONGST SMALL-SCALE DAIRY FARMERS IN QWAQWA AND ITS RELATIONSHIP WITH THE MANAGEMENT PRACTICES USED

ABSTRACT

Questionnaire was distributed during the period of November and December 2003 in the QwaQwa area of the Free State Province with the aim of assessing the knowledge and management practices adopted by small-scale dairy farmers in controlling mastitis disease. Each questionnaire (Annexure 1) was used to gather data from sixty randomly selected dairy farmers. The average age of the participant farmers was 55 ± 13 (SD) years. Only 28% of the farmers had a secondary or tertiary level of education. The average dairy herd size was 39 ±36 (SD) animals. The cows in milk constituted 36% of the herd, while the remainder were dry cows (14%), heifers (16%), calves (30%) and bulls (4%). When farmers were grouped into their daily milk production capacity, 57% reported producing 1 to 50 litres, 20% 51 to 100 litres, and 23% more than 100 litres per day. Only 8.3% of the farmers reported having experienced mastitis problems. The average clinical mastitis cases reported per farm per year were 1.6 ± 1.6 (SD) cases. The average incidence rate of clinical mastitis was 18.5% (calculated as the number of clinical cases divided by the number of cows in milk). As expected, the mastitis cases reported by farmers showed a positive association with the number of cows in the herd. The incidence of mastitis reported for 1 to 50 litres, 51 to 100 litres and approximately 100 litres daily milk production groups was 20.5%, 24.7% and 8.1% respectively; however, the difference between the groups was not significant due to a large number of sampling errors. No other management practices, such as having a separate milking area, washing hands and teats before milking, and using disinfectant for teats, appeared to have an influence on the incidence of clinical mastitis reported by farmers.

Keywords: Questionnaire, clinical mastitis, dairy cows, management practices

3.1 INTRODUCTION

This chapter presents and discusses the farmers' knowledge and management practices in respect of mastitis control on small-scale dairy farms in QwaQwa. It describes various processes that constitute good management practices, and discusses the way in which they influence the incidence of mastitis. Such good management practices include those that limit the spread of contagious CM in the milking area. Although mastitis has been recorded as one of the major diseases of economic importance in the dairy industry worldwide (Radostits *et al*., 1999). The major health constraints in QwaQwa include tick-borne diseases and helminthiosis (Hlatshwayo *et al*., 2000). On the other hand, mastitis is also increasingly being incriminated as an important disease in dairy animals (Schepers & Dijkhuizen 1991; Mdegela *et al*., 2005).

This study focuses on the influence of certain management practices on the occurrence and control of mastitis in dairy cows amongst small-scale farmers. It has been proven that poor management practices by farmers are due to a lack of sufficient information, knowledge, training, infrastructure (e.g. clean water, sanitation, electricity, etc.) and basic facilities, are reported to contribute to the increased incidence of mastitis on dairy farms (Personal communication, Vermeulen, 2004). Small-scale farmers operate in a context of rising local population pressure, with a very small resource base and a low standard of living. Dairy farming in QwaQwa is dominated by small-scale farmers, and, according to Masiteng (2000), among the small-scale dairy farmers in the north-eastern Free State, many farming operations are still based on the traditional way. A study on the relationship between mastitis disease and management practices in QwaQwa has not previously been conducted.

The objective of this study was to investigate the level of the mastitis problem, as well as farmers' knowledge when it comes to mastitis control on small-scale dairy farms in QwaQwa.

3.2 MATERIALS AND METHODS

3.2.1 Study site

The research was conducted in the former self-governing territory of QwaQwa, which is situated in the north-eastern region of the Free State Province. The QwaQwa Transitional Rural Council (TRC) area of jurisdiction represents the entire QwaQwa magisterial district, excluding the area of jurisdiction of the Phuthaditjhaba Transitional Local Council (TLC). The QwaQwa TRC consists of mostly peri-urban communities. The area is divided into five agricultural wards. The total surface area of QwaQwa comprises 1,45 million hectares. This area of jurisdiction does not include the state land adjacent to QwaQwa that is presently being redistributed to former QwaQwa residents (Van Zyl, 1998). The study area is surrounded by Lesotho and the KwaZulu-Natal Province, and includes the entire district of Witsieshoek, as well as parts of the Harrismith, Kestell and Bethlehem Districts (Claassens *et al*., 1991).

QwaQwa is one of the few rural areas in South Africa that resemble an urban area. An influx has been experienced since 1994, although the urbanisation rate might have declined in recent years due to fewer job opportunities in the area. The unemployment rate for this area is still estimated to be 42% (Van Zyl, 1998). In the QwaQwa area, individuals are granted crop production land on a traditional basis, whereas grazing rights are allocated and utilised on a communal basis.

3.2.1.1 Topography and drainage

The study area's topography is characterised by its mountainous landscape. This relates to the geology of the area, with the Drakensberg mountain range to the south as the most prominent relief aspect. Well-defined drainage patterns, which have been established through erosion, drain mainly in a northerly direction, and many rivers and streams have their spring within the study area. This area falls within the catchments area of the Vaal River, and, apart from the Fika Patso and the Metsi-matsho dams, no major water schemes occur within the QwaQwa area. The topography is generally characterised by an uneven landscape with complex

drainage systems. Large parts of the area are inhabitable and fall within flood-line areas. The existence of high areas, namely the Lesotho Highlands, as the southern boundary of the area, has a definite influence on both the climate and the drainage pattern (Free State Department of Agriculture, 1998).

3.2.1.2 Agricultural sector

3.2.1.2.1 Vegetation

The north-eastern Free State is characterised by palatable climax grass species. Around communal lands, palatable climax species are being depleted due to uncontrolled and continuous defoliation and are being replaced with unpalatable pioneer species, i.e. veld retrogression is taking place. The veld has deteriorated, making soil more prone to erosion and the formation of gullies. Inadequate grazing forces cattle to overstep the boundaries of neighbouring farms. Such cattle are often impounded, which results in social conflict between the two parties (farmers on state land and those on communal land). As in the tribal areas of, *inter alia*, Kwazulu-Natal, the crop production land in QwaQwa is under-utilised, whereas the grazing is over-utilised (Masiteng, 2000).

3.2.1.2.2 Climate

QwaQwa is located in a summer rainfall region with an average annual rainfall of about 800mm mostly between October and March. The average maximum summer temperature is around 26^0C with a minimum winter temperature between -3^0C and -6^0C. Snow is also present during the winter months. Research has shown that the climate in the north-eastern Free State is not regarded as an obstacle to any agricultural or industrial development. The area has a flourishing industrial area and has exceptional agricultural potential. No prominent prevailing winds are prevalent in the region, but katabatic and anabatic flows from the higher lying Lesotho can be present, causing a drop in temperature that can be aggravated by snowfall on the Drakensberg Mountains. The latest statistics regarding the direction and speed of winds in QwaQwa, as supplied by the Weather Bureau Office of the Department of Environmental Affairs, show that the

highest average wind speed is 4.3 metres per second. The highest direction frequency (15.7 percent) is from the west, with an average speed of 4 metres per second (Free State Department of Agriculture, 1998).

3.2.1.3 Study sample selection

According to the information provided by the Ministry of Agriculture QwaQwa District Office, there are 103 registered small-scale dairy farms in the region. From these farms a total of 60 small-scale dairy farmers were selected to participate in the study, using a simple random selection procedure. The owners or managers of the selected farms participated in the process by answering the questionnaire that was in Sesotho language. The questionnaire was pre-tested on six farmers that participated in the study. The questionnaire was not handed to the small-scale dairy farmers to fill in but was only used by the interviewer.

3.2.1.4 Development of the questionnaire

According to Scholl *et al*., (1992) dairy farm management questionnaires have become a common method of gathering management information in studies on the relationships between management and production or diseases. In this study a questionnaire was designed to investigate the incidence of clinical mastitis in small-scale dairy farms and their management practices.

3.2.1.5 Data collection

The data collection process was conducted at the farmers' homes, and each farmer was asked to answer a set of questions related to personal and on relevant dairy management practices and aspects of mastitis control and prevention (Plate 3.1). Data was collected during the period of November and December 2003. Each interview took approximately thirty minutes per farmer. The questionnaire was divided into four categories (Appendix 1). The first category focused on the farmers' personal particulars such as age, gender, marital status, and level of education; the second category focused on dairy

herds and facilities; the third category focused on the farmers' knowledge of mastitis; and the fourth category focused on cow-milking management.

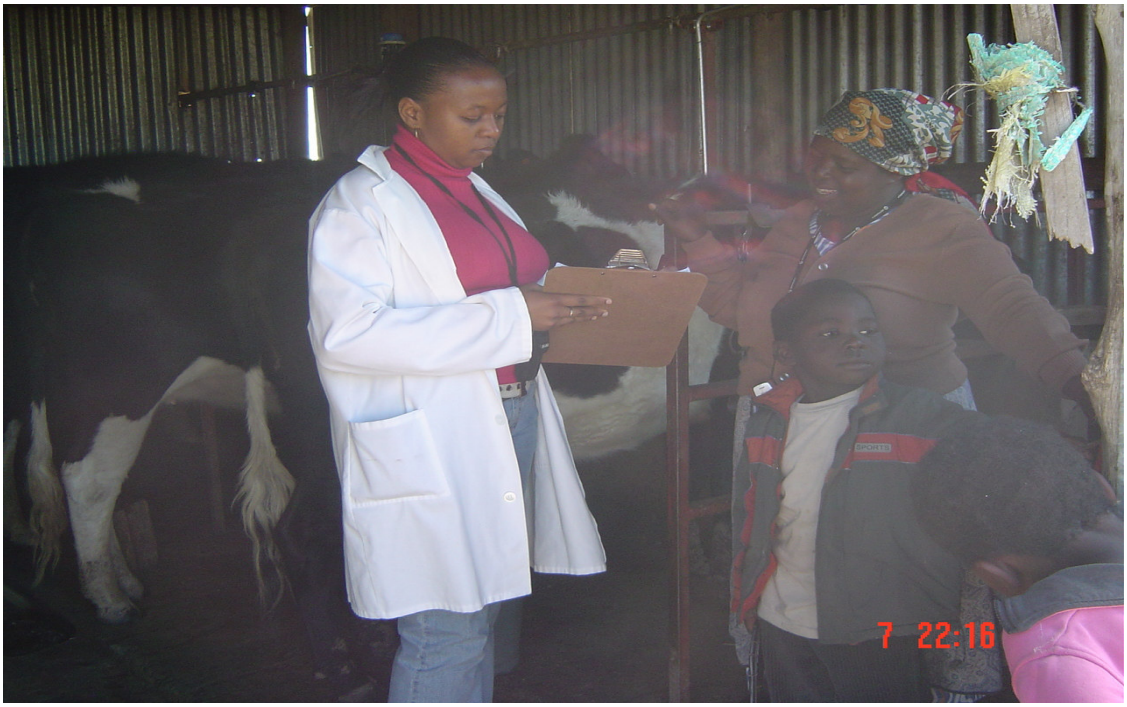

Plate 3.1: During interview

3.2.1.6 Data preparation and statistical analysis

Data gathered from the questionnaire were captured on a Microsoft Excel worksheet and analysed using the general linear model (GLM) and the frequency procedures of statistical analysis systems (SAS) (SAS, 1999). The relationship between management practices and CM cases was tested using the chi-square statistic for differences in proportions. The relationship between management practices and milk production and between farmers' personal particulars and management practices was also tested using the chi-square test.

The new variable mastitis prevalence rate was calculated by dividing the number of cases reported by the number of cows and multiplying the result by 100. The effect of several management practices and farmers' personal particulars on the mastitis prevalence rate was also tested using GLM procedure (SAS, 1999).

To calculate the stocking density per farm in the study area, different classes of dairy animals reported by farmers were converted to a common unit using the tropical livestock unit (TLU = 250 kg animal) (Heady, 1975). The animals in the study population were either purebred *Bos Taurus* (Holstein-Friesland, Jersey, Drakensberger and Dairy Shorthorn) or their crossbreeds and were large framed, and therefore the following TLU was used as a base for conversion: cows = 1.3 TLU, heifers = 0.75 TLU, calves = 0.5 TLU, and bulls = 1.5 TLU.

The calculated probability values for chi-square or GLM statistics were declared significant if $P < 0.05$.

3.3 RESULTS AND DISCUSSION

3.3.1 Biographic particulars of dairy farmers in QwaQwa

The youngest farmer in the study was 28 years of age, while the oldest was 84 years of age. The mean age of the small-scale dairy farmers in QwaQwa was 55±13 years (Table 3.1). The result is similar to the average age of 55 years reported by Nell (1998) for the small-stock farmers in QwaQwa. Williams (1994) indicates that most farmers in the rural areas of Southern Africa are too old to farm, while Claassen (1998) reported that 53% of farmers in the QwaQwa area are older than 50 years of age, and a similar situation prevailed in this study. On average, dairy farmers in QwaQwa support four family members, children and other relatives, and provide employment opportunities for approximately two additional people (Table 3.1). Participant farmers' experience in the dairy farming business ranged from 2 to 29 years, with 9.5 median years of farming experience. This is not in line with the findings of Marfo (2001), who found farming experience to vary between 5 and 50 years, but is similar to Maphalla's (2004) finding that farming experience ranged from 3 to 27 years (Table 3.1). Males (86.7%) dominated dairy farm ownership, while females owned only 13.3% of the farms (Figure 3.1). The majority of farmers (48.3%) had a primary school education, while only 28.4% had secondary school training or higher qualification, and 23.3% had no education whatsoever (Figure 3.2).

TABLE 3.1: Mean, median and ranges for age of farmer, experience, number of dependants, and number of employees hired by dairy farmers at QwaQwa (N = 60)

Variables	Mean±s.e.[1]	Median	Range
Age (years)	55.3±1.68	57	28-84
Experience (years)	9.52±0.73	2	2-29
Dependents (No.)	4.76±0.37	4	0-13
Employees (No.)	1.58±0.35	1	0-9

[1]s.e=standard errors

FIGURE 3.1: Dairy farm ownership by gender in QwaQwa

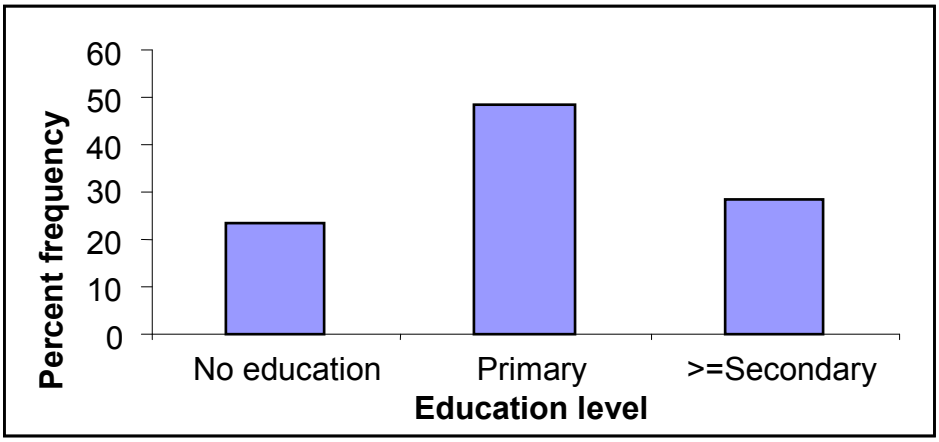

FIGURE 3.2: Education level of dairy farmers in QwaQwa

3.3.2 Dairy herd and facilities

3.3.2.1 Average farm size and dairy herd composition

The mean farm size was 747.4 ha and the mean grazing area was 462.96 ha. In any dairy herd the majority of cows should be lactating, while a few should be dry, and heifers should be raised to replace older cows or new producers (Steenkamp, 1999). The average dairy herd in QwaQwa consisted of 13.7±2.5 (36%) milking cows, 5.53±0.83 (14%) dry cows, 6.5±1.06 (16%) heifers, 12.3±1.36 (30%) calves, and 1.7±0.44 (4%) bulls (Table 3.2). The results of this study indicate an ideal dairy herd composition, although there were 50% more dry

cows in relation to milking cows. Masiteng (2000) found the average number of milking cows to be 10.8 cows per day, which means that since the year 2000, the average number of cows milked per day per farm has increased by 2.9 cows. A total of 55 farmers (91.7%) indicated that they also kept other livestock such as poultry, small stock, horses, beef cattle and pigs on their farms, and very few (8.3%) were farming only with dairy animals. Most farmers (76.7%) reported keeping their dairy cows in the veld, after milking because they could not afford to purchase cattle feed. The results of this study concur with those of a study conducted by Marfo (2001), who reported that 92% of farmers relied on the veld as the main source of grazing for their cattle, with 8% keeping their cattle in kraals.

TABLE 3.2: Average farm size and dairy herd composition of the study farms (N = 60)

Variable	Mean ± s.e.	Median	Range
Farm area (ha)	747.4 ± 106.5	2000	58 – 5084
Grazing area (ha)	462.96 ± 49.9	1000	38 – 1589
TLU	38.53 ± 5.09	80.9	6.4 – 265.5
Stocking density (ha/TLU)	19.7 ± 2.90	45.9	0.94 – 104.1
Milking cows (No.)	13.7 ± 2.5	28	2 – 138
Dry cows (No.)	5.53 ± 0.83	14.5	0 – 40
Heifers (No.)	6.5 ± 1.06	15	0 – 50
Calves (No.)	12.3 ± 1.36	26.5	1 – 50
Bulls (No.)	1.7 ± 0.44	3	0 – 25

SE = Standard error
TLU=Tropical livestock unit

3.3.2.2 Level of milk production and marketing

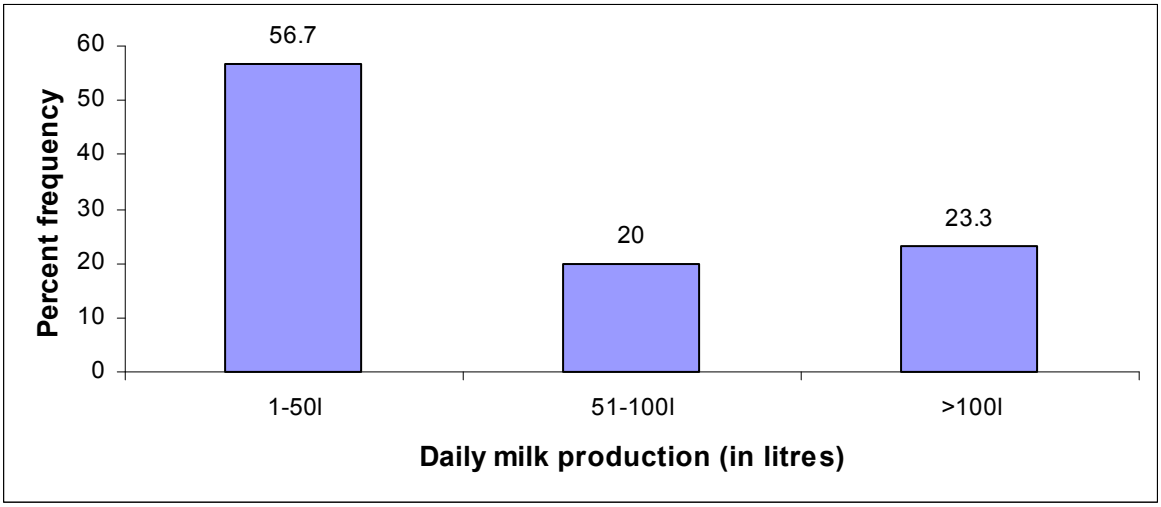

FIGURE 3.3: Percentage of farmers according to total daily milk production

Figure 3.3 shows the percentage of farmers categorised according to total daily milk production. The majority of farmers (56.7%) reported producing between 1 and 50 litres per day, while 20 and 23.3 percent were reported to produce a total of 51 to 100 litres and >100 litres per day respectively. The sale of milk is the primary source of income for most small-scale dairy farmers in QwaQwa. Even though the overall milk production level in the area is low (1-50 litres per milking cows per day), the majority of farmers (68.3%) reported selling milk to milk-processing companies such as Nestlé and QwaQwa Thaba Dairies. Some farmers are selling milk in its raw, non-pasteurised state to their neighbours. Although these farmers wished to sell their milk to processing companies, they were hindered by certain constraints such as a lack of bulk tanks and transportation. Government legislation specifies that no person is allowed to sell raw milk or milk that has become sour except in the areas of jurisdiction of the local authorities (Foodstuffs, Cosmetics and Disinfectants Act, 1972). Farmers not selling (31.7%) reported that the milk produced on their farms was for their own household consumption.

As expected, the difference in the level of daily milk production reported by farmers was dependent on the number of cows milked ($P<0.05$). The average number of cows milked on farms producing 1-50*l*, 50-100*l* and >100*l* were

6.2±4.3, 10.9±5.02 and 34.3±32.1 cows respectively.

3.3.3 Mastitis problem and dairy herd management practices

Table 3.3 summarises the frequency distribution of all management practice variables considered significant in mastitis control.

TABLE 3.3: Frequency distribution of farmers' responses regarding the most common hygienic management practices (N = 60)

Variables	Frequency	Percentage (%)
Teat cleaning		
Always	50	83.3%
Never	10	16.7%
Teat cleaning & drying style		
Bucket of water & shared towel	49	81.6%
Towel for each cow	11	18.3%
Frequency of milking		
Once daily	38	63.3%
Twice daily	22	36.7%
Punctuality of milking time		
Yes	40	66.7%
No	20	33.3%
Milking method		
Manual	57	95%
Mechanic	3	5%
Teat disinfection before or after milking		
Yes	3	5%
No	57	95%
MA disinfection		
Yes	29	48.3%
No	31	51.7%
Frequency of cleaning and disinfecting MA		
After every milking	14	23.3%
Three times per week	14	23.3%
No cleaning or disinfecting	32	53.3%
Hand washing		
Always	56	93.3%
Never	4	6.7%
Separate calving area		
Yes	40	66.7%
No	20	33.3%
Separate MA		
Yes	9	15%
No	51	85%

Table 3.3 continued

Variables	Frequency	Percentage (%)
Cow barn		
Always dry and clean	38	63.3%
Wet and muddy during rainy periods	15	25%
Wet and muddy most of the time	7	11.7%
Frequency of cleaning cow barn		
After every milking	3	5%
No cleaning	57	95%
Removal of foremilk		
Yes	38	63.3%
No	22	36.7%
Stripping onto floor		
Yes	8	13.3%
No	52	86.7%
Dry period		
1 month or less	2	3.3%
2 months	7	11.7%
3 months or more	51	85%
Records kept of clinical mastitis cases		
Yes	5	8.3%
No	55	91.7%

MA = Milking area; $P < 0.05$

Management practices have been and will continue to be the most effective means of preventing mastitis (Schutz, 1994). With regard to teat cleaning, Table 3.3 shows that the majority of farmers (83.3%) indicated that they washed the teats before milking, while 16.7% reported that it was not necessary to wash the teats, because calves were allowed to suckle first. Costa *et al*., (2003) found that farmers who allowed calves to suckle before milking experienced a higher rate of positive CMT (66.8%) than those who did not allow this (45.3%), as well as a higher infection level (81.4% and 50.6% respectively). When asked what they used to clean teats and dry off washed teats before milking, 81.6% indicated that they use a bucket of water and a shared towel on all milking cows in the herd, while 18.3% indicated that they use an individual towel for each cow. The use of a shared towel or even an individual towel without disinfecting it between milkings is not recommended in milking cows (Steenkamp, 1999). The use of disposable paper towels is recommended, as they are only used once and then discarded, which eliminates the possibility of cross-contamination (Hobbs & Roberts, 1993). According to Torgerson *et al*., (1992) the use of an individual disposable cloth for

each cow is considered to be the most practical strategy for mastitis control. Drying with a shared towel has been shown to spread mastitis, especially of the contagious type (Fox & Gay, 1993).

For decades dairy farmers believed that it was best to milk cows only twice per day (Pritchard, 2003). Most farmers (63.3%) in QwaQwa are taking the approach of milking in both the morning and the evening, while 36.7% are milking their dairy cows either in the morning or the evening. Kaartinen *et al*., (1990) found that cell counts were significantly lower in cows milked twice daily compared to once daily throughout the lactation. Correct milking procedures are important regardless of whether cows are milked by hand in traditional dairying situations or with modern milking machines (Thirapatsakun, 1989). The majority of the farmers (95%) milked their cows by hand, while only a few (5%) used milking machines. The majority of the farmers (66.7%) kept punctually to a specific milking time, while 33.3% indicated that they did not keep to a specific milking time, because they were not selling the milk.

Pre-milking and post-milking teat disinfection reduces infection by major and minor pathogens (Watts *et al*., (1988). The majority of the farmers (95%) did not disinfect teats before and after every milking, which means that only 5% did so. Barkema *et al*., (1999) found PMTD to be associated with low bulk milk somatic cell count (BMSCC) in herds.

Few farmers (15%) had separate milking area, with the majority (85%) not having a single milking area. With regard to milking area disinfection, 51.7% of farmers reported that they did not disinfect the milking area. Nearly half the farmers (48.3%) who practised milking area disinfection used *Jeyes Fluid* as the disinfectant. There is no information in the literature on milking area disinfection with *Jeyes Fluid*, and it would therefore be difficult to draw a conclusion on its effectiveness. The milking area should be cleaned and disinfected after every milking in order to prevent bacteria from multiplying (Horner & Randles, 1995). The cleanliness of the milking area depends, of course, on the frequency with which the milking area is cleaned. Therefore, with regard to the frequency of cleaning and disinfection of the milking area, 53.3% of the farmers indicated that

their milking areas were never cleaned or disinfected. Only 23.3% of the farmers cleaned and disinfected the milking area after every milking, while 23.3% reported cleaning and disinfecting three times per week.

The majority of the farmers (63.3%) described their cow barn as being always dry and clean. According to Kerro & Tareke (2003) wet and muddy stalls, especially during the rainy season, can be a predisposing factor for increased infection rates. The results of this study indicate that 25% of the farmers (15) described their stalls as being wet and muddy during rainy periods, while 11.7% of the farmers described them as being wet and muddy most of the time. The cleanliness of the milking-cow barn also depends on the frequency with which the barn is cleaned. Farmers were therefore questioned on the frequency with which they cleaned their cow barns, and it emerged that only three farmers (5%) cleaned the milking-cow barn after every milking. The majority of the farmers (95%) reported that the reason they did not clean their barns was because they kept their animals in the veld, with some reporting that they burned the veld instead of cleaning.

The majority of the farmers (93.3%) reported that they always washed their hands with soap before milking, while only (6.7%) of farmers never washed their hands. Bartlett *et al*., (1992) showed that the use of a separate calving unit was associated with a lower incidence of CM. Most of the farmers (66.7%) had a separate calving pen, while 33.3% had no such pen. The majority of the farmers (91.7%) did not have a separate milking area, while 8.3% reported having separate milking area. A lower IRCM caused by *Escherichia coli* was associated with the presence of a separate milking area for diseased cows (Barkema *et al*., 1999).

Stripping of milk from each quarter is beneficial, because it allows for the early detection of CM and also encourages milk letdown, eliminates micro-organisms in first milk (Thirapatsakun, 1989). The majority of the farmers (86.7%) do not strip milk onto the floor, while 13.3% do so. Schukken *et al*., (1991) found that stripping milk onto the floor is a risk factor for *Staphylococcus aureus* mastitis. Sixty-three percent of the farmers remove the foremilk and inspect it for any signs

of CM, while 36.7% do not do so. Although fore-milking is an accepted practice (Steenkamp, 1999), it causes other cows to be exposed to mastitis pathogens when the stripped milk is not disposed of correctly (Peeler *et al*., 2000), or when the milker transmits infection from cow to cow via contaminated hands (Schukken *et al*., 1991).

The cow's udder needs time to rest so that it can regenerate new milk-secreting cells. The recommended dry period should be at least 40 days in duration (Jones, 1998). The majority of the farmers (85%) allowed their dairy cows a drying-off period of three or more months. Only two farmers (3.3%) allowed a period of one month or less, and 11.7% allowed a two-month drying-off period. Peeler *et al*. (2000) report that a brief drying-off period of fewer than 40 days protects cows against mastitis, and shortens the period of risk for the establishment of an IMI. In addition, antibiotic dry therapy provides protection against sensitive bacteria for a greater proportion of the dry period, also possibly resulting in lower infection rates and subsequent CM (Peeler *et al*., 2000). The majority of the farmers (75%) did not treat the cows for mastitis when they were dried off, with only a few farmers (25%) following this practice.

Keeping records is an indication of good management (Peeler *et al*., 2000). The majority of the farmers (91.7%) indicated that they did not keep records of mastitis cases, while 8.3% kept such records.

The majority of the farmers (91.7%) had some knowledge on the mastitis disease, while 8.3% had no such knowledge. Most of the farmers (76.7%) reported observing mastitis problems always, while 23.3% reported never observing such problems. When farmers were asked what they would do upon noticing mastitis in some of their cows, only 36.2% indicated that they would separate them from the healthy ones, while 63.8% indicated that they would keep all the cows together.

Slightly less than half the farmers (46.7%) reported that they always strip test for mastitis before milking, while 53.3% of the farmers reported never testing for clinical mastitis. Milk should never be stripped directly into the hand, because the

procedure spreads organisms from teat to teat and cow to cow (Thirapatsakun, 1989) and may also result in transfer of *Staphylococcus aureus* from the hands of the milker (Peeler *et al*., 2000). When farmers were asked what they used to test for and detect mastitis, 10.7% used the CMT or strip cup to test for mastitis, while more than half the farmers (57.1%) used either a bucket, cup, milk sieve or hand to test for mastitis and observe for any changes in the milk, and 32.1% tested for mastitis by simply stripping milk onto the floor and observing any changes in the milk. This implied that farmers were not able to detect all SCM cases due to limited or no knowledge of necessary diagnostic facilities like CMT plate and reagent. Only three farmers were able to detect SCM cases.

On average, dairy farmers in QwaQwa reported experiencing 1.6±0.21 cases of mastitis in their herds per year. The average incidence rate was 18.43+3.11% (Table 3.4), which means that per 100 milking cows, on average there would be 18 cases of mastitis cows in one year.

TABLE 3.4: Mean and standard errors of mastitis cases and incidence reported by farmers

VARIABLE	MEAN ± S.E	RANGE
Mastitis cases (No.)	1.62 ± 0.21	0 – 8
Mastitis incidence (%)[1]	18.48 ± 3.11	0 – 133

[1]mastitis incidence = number of clinical mastitis cases / milking cows * 100/year

According to Quinn *et al*., (1994) the accepted value for mastitis incidence is 10-12%, while higher values of 16-65% put the dairy business at high risk. The number of mastitis cases reported increased significantly ($P < 0.05$) with the level of daily milk production – which is expected, because the level of daily milk production is a reflection of the number of cows the farmer is milking. On the other hand, the mastitis prevalence rate was higher on farms with a low level of daily milk production than those producing a high quantity; however, the difference was not statistically significant due to a large number of sampling errors (Table 3.4). The low level of mastitis incidence for farms producing high

levels of milk could be as a result of better mastitis control programmes on these farms, as those are the farms that supply milk to the processing companies and have high quality control standards. This finding is in contrast to that reported by Peeler *et al.* (2000) who found that the incidence rate of CM was higher in herds with an average lactation yield of greater than 7500 litres per cow per annum.

TABLE 3.5: Mean and standard errors of mastitis cases and incidence of mastitis for different levels of total daily milk production

Level of daily milk production	N	Mastitis cases (No.)	Incidence of mastitis (%)
1 – 50 litres	34	1.15 ± 1.52^{a}	33.3 ± 12.45
51 – 100 litres	12	1.9 ± 1.16^{b}	35.2 ± 13.45
> 100 litres	14	2.5 ± 1.8^{c}	9.4 ± 12.36

Means with different superscripts within the column are different at $P < 0.05$.

The following management practices were associated with a higher rate of mastitis ($P < 0.05$): Separate milking area, hand washing, teat cleaning, and teat disinfection. Farmers who reported having a separate calving area (13.5%) had a significantly higher rate (*P = 0.0041*) of mastitis compared with those not having a separate calving area (7.5%). This could be because farmers who reported having a separate calving area had a high mean number of cows (23.1) on their farms, while those not having a separate calving area had a low mean number of cows (12.9) or associated with sampling error. No significant difference was detected in the mean rate of mastitis reported between farmers that did not wash their hands before milking (10.2% number of cases) and those that did (11.3% number of cases). Farmers who reported having a separate milking area and who always cleaned the teats before milking and who also disinfected the teats had a significantly lower rate of mastitis. Statistical significant ($P>0.05$) association was not found between the management practices and the rate and incidence of CM cases.

3.4 CONCLUSIONS AND RECOMMENDATIONS

The designed questionnaire survey of the study addressed quite a number of aspects, including biographic particulars of the farmers, dairy herds and facilities, occurrence of clinical mastitis, and dairy herd management practices. The results of the study indicate that although most of the farmers were adhering to some management practices that reduce mastitis such as teat cleaning, hand washing, and having a separate calving area, there is still a need for farmers to improve their hygienic management practices. Lack of record keeping resulted in many biases in this study, because farmers were unable to accurately answer the questions – they simply gave answers for the sake of answering. The standard of management and hygiene practices were relatively poor in the studied farms.

On the basis of the results obtained in this study, the following recommendations are suggested:

- Improve record keeping system
- Promote use of separate paper or towels for teat cleaning
- Train extension officers on modern mastitis control techniques
- Lack of diagnostic kits (such as CMT) during milking should be addressed

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CHAPTER 4

FACTORS AFFECTING INDIVIDUAL COW SOMATIC CELL COUNT AND MILK COMPOSITION ON SMALL-SCALE DAIRY FARMS IN QWAQWA

ABSTRACT

The study was conducted with the aim of investigating factors affecting individual cow SCC and milk components on small-scale dairy farms in the QwaQwa area. A total of 120 lactating cows from 30 randomly selected farms were analysed for SCC using the California mastitis test (CMT) kit in the farms and Fossomatic cell counter in the laboratory. For chemical composition a Dairylab II milk analyser was used. On average, the concentration of fat, protein, lactose and SNF in milk was 4.41%, 3.40%, 4.87% and 8.66% respectively. With the exception of parity, all other factors studied (breed, daily milk yield, and udder, rear leg and area cleanliness) did not have a significant influence on SCC, TPC, and CMT score ($P > 0.05$). The SCC ranged from 199 ± 1.4 (cells/ml) for the Jersey breed to 400.3 ± 1.4 (cells/ml) for the Brahman breed. Both SCC and CMT increased ($P<0.01$) from first to fourth parity. Amongst milking management factors, washing of hands made a significant difference ($P<0.05$) to CMT and TPC count. No other management and animal-related factors studied had an influence on milk components ($P>0.05$). There was significant positive correlation between SCC and CMT score ($r = 0.6$). Somatic cell count and CMT produced showed significant negative correlations ($r=-0.4$; $r=-0.37$ and $r=-0.4$; $r=-0.39$) with lactose and SNF. Thus this study showed that CMT could be used to detect sub-clinical mastitis in small-scale dairy farms. It also revealed the importance of cleaner dairy operation to minimize mastitis risk and to produce hygienic milk from small-scale dairy farms.

Keywords: California mastitis test, total plate count, sub-clinical mastitis, management practices

Abbreviation key: SCC = somatic cell count, TPC = total plate count, CMT = California mastitis test

4.1 INTRODUCTION

This chapter discusses factors (breed, parity, daily milk yield, rear leg cleanliness and milking area cleanliness scores) affecting SCC, CMT and milk composition. Management practices such as a separate calving area; hand washing, teat cleaning before milking, and milking area disinfection after milking were also investigated in respect of their influence on SCC, CMT score and TPC.

The total SCC of milk can vary because of a number of external factors. Bovine mastitis, or inflammation of the mammary gland, is the most important cause of elevated milk SCC, and numbers of lactations are also known to influence milk SCC (Kelly *et al*., (2001). The level of SCC has been reported to be influenced by parity and stage of lactation (Kramer *et al*., (1980).

The composition of milk is markedly influenced by the health status of the udder (Fernandes, *et al*., 2004). The occurrence of inflammatory process or mastitis generally leads to an increase in SCC in milk, which has been associated with changes in milk components and properties (Auldist and Hubble, 1998).

The composition of milk differs within species, especially dairy species. The lactose content of milk is fairly constant amongst breeds, while protein varies to some extent, but milk fat varies extensively. Yields of fat, protein, solids-not fat (SNF), and total solids are highly and positively correlated with milk yield. Yields of milk, fat, protein and total solids are not easily impacted by genetics. While milk fat content remains relatively constant, milk protein content gradually decrease with advancing age. Mastitis is associated with decrease in lactose and fat in milk because of a reduced ability of the mammary gland to produce these components. Fat yield decrease due to a decline in milk production, while protein content may undergo little change (Waldner *et al*., 2004).

Factors such as breed, parity, level of milk production, hygienic management of dairy farms were reported to affect SCC, CMT, TPC and milk composition in large dairy operations (Barkema *et al*.,1999; Sevi *et al*., 2000; Smit *et al*.,2000 and

Tadich *et al*., 2003;). However, there is no such study on small-scale dairy farms in South Africa.

The objectives of this study were:

1. To investigate factors affecting individual cow somatic cell count (SCC), milk components and certain management and animal-related factors in the milk of dairy cows in QwaQwa.
2. To compare the California mastitis test (CMT) with the SCC methods for detecting sub-clinical mastitis in dairy cows under QwaQwa farming conditions.
3. To assess the relationship between SCC and milk composition.

4.2 MATERIALS AND METHODS

4.2.1 Study site

A detailed description of the study site is given in Chapter 3. Briefly, the study was conducted in the QwaQwa area, located in the north-eastern part of the Free State Province.

4.2.2 Collection of milk samples

A total of 120 cows were sampled once for visual udder health assessment for on-farm CMT scores and SCC testing. For reliable statistical diversions, equal numbers of cows (four) were sampled from each participating farm. In this study the total number of farms was reduced to 30 (N = 30). Furthermore, cows from each farm were selected randomly from all available milking cows at the time of the farm visit. For all selected cows, age, parity, daily milk production and breed were recorded and later used as a potential source of variation in the analysis of SCC, CMT and TPC (Appendix 2).

Milk sampling was done either in the morning and evening milking, and samples were collected immediately prior to regular milking in a milking area (Plate 4.1). A sample of milk from each lactating cow in the milking herd was collected and processed separately. Each teat was cleaned with warm water, wiped dry with an individual towel, and disinfected with 70% ethyl alcohol (ethanol) on cotton wool, starting with the farthest teat and working towards the nearest teat (to avoid contamination). Two to three strips of foremilk were removed. Samples were then collected by the normal hand-milking technique. Ten to fifteen millilitres of milk were taken in a 20ml sterile bottle. The sterile bottle was opened under the teats to prevent anything coming into contact with the mouth of the bottle. Three to four millilitres of milk from each quarter, starting with the closest quarter and working towards the one farthest away, were collected. The bottle was closed immediately before it was removed from beneath the teats.

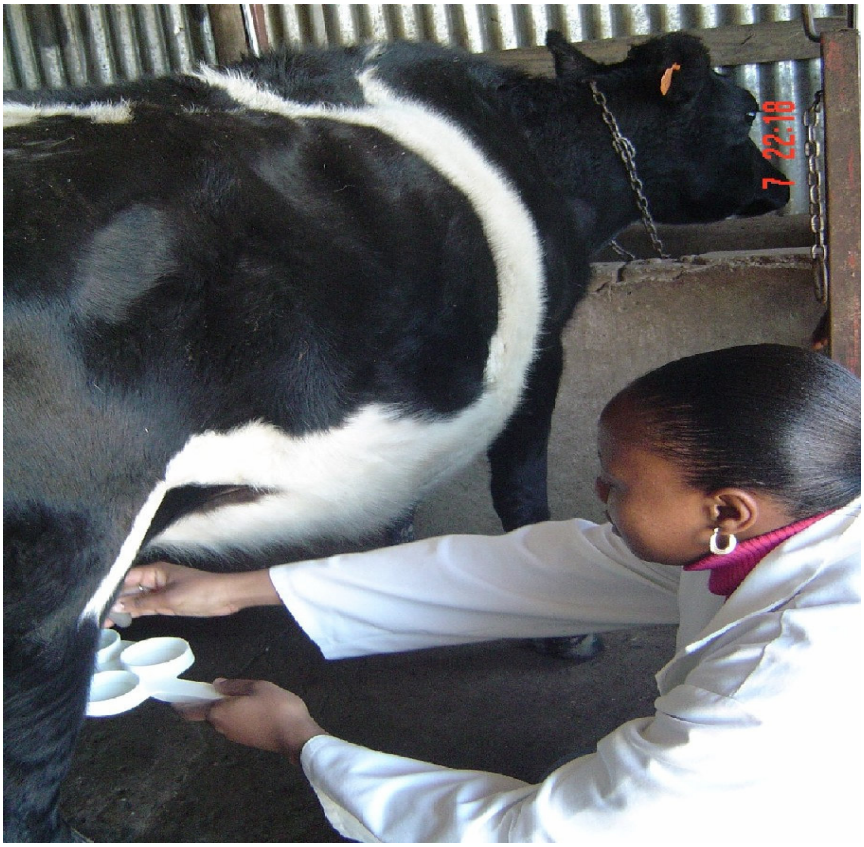

Plate 4.1: Testing of milk using CMT

The samples were immediately placed in a cooler box containing ice bricks and then transported to the Nestlé Company in Harrismith on the same day for the analysis of SCC, TPC and milk composition. If the milk sample was going to be transported the next day for the analysis, it was kept in a 4^0C in a refrigerator. The following records, as described by Grace *et al*., (1992), accompanied all samples to the laboratory: Time and date of sampling, product, cow identity, place/farm owner, and sampler's name.

4.2.3 Cleanliness scoring for udder, rear legs and milking area

On the day before each milk sampling, all the cows to be sampled were examined carefully to score for the presence or absence of CM (Appendix 2).

According to Ruegg (2003) udder hygiene scores (UHS) can be easily and efficiently obtained during milking using a visual scoring system. Scoring is a one-way method of evaluating cow and milking area cleanliness and symptoms of CM

on teats. For scoring CM effects on udder and teats, the scale from 1 to 3 was used. Score 1 indicated a normal teat, 2 indicated one teat with CM symptoms, and 3 indicated two or more teats with CM symptoms (Appendix 2). Udder and rear leg cleanliness were assessed during milk sample collection in the milking area and were also scored on a scale from 1 to 3. Score 1 indicated that the udder and rear leg were absolutely clean, score 2 indicated slightly dirty, and score 3 indicated heavy soiling with dung or muddy material. The milking area was also scored using the same scale (1 - 3) as for udder and rear leg (Appendix 2).

4.2.4 Milk analysis

All samples were analysed using the CMT scoring (Plate 4.2) and SCC (Appendix 3).

Plate 4.2: California mastitis test

4.2.4.1 California mastitis test (CMT) and procedure

The CMT is a rapid cow-side (on farm) test for early detection of mastitis and for years has been a trusted tool of dairy producers. The CMT was developed to test

milk from individual quarters at the side of the cow. The test may also be applied to bulk-tank milk and other blended supplies (Hinz *et al*., 1992).

The CMT has the advantage of being a simple and inexpensive cow-side test that provides real-time results (Sargeant *et al*., 2001). The CMT procedure was developed for rapid identification of mastitis-infected cows on a farm. When mastitis-infected milk is mixed with the CMT reagent it precipitates, and the level of precipitation indicates the severity of mastitis infection. The CMT is a simple rapid and qualitative method for on-farm application, although it is less accurate than SCC. The test score is subjective and dependent on the experience of the tester. In this study the CMT procedure was used to establish the relationship of the test score with SCC for dairy cows in QwaQwa.

The milk was collected from individual quarters. The first stream of milk was discarded, and then the drawn milk from each quarter was poured into the corresponding cup in the testing paddle. The excess milk was poured off by tilting the testing paddle until equal volumes of 2ml remained in each cup of the paddle. Two millilitres of CMT reagent were then added. The paddle (or cup) was then gently rotated in a circular pattern for 10 seconds so that the milk and the reagent could thoroughly mix (Hoblet *et al.*, 1993). The results of the CMT were interpreted as described by Hoblet *et al*.1993 and are summarised in Table 4.1. Scoring or interpretation of CMT reactions for cow's milk was selected. Score 1 indicated negative, i.e. the mixture remained liquid and no precipitation formed; score 2 indicated weak positive, i.e. a distinct precipitate formed; and score 3 indicated distinct positive, i.e. the mixture thickened immediately (Table 4.1).

TABLE 4.1: California mastitis test (CMT) interpretation

CMT SCORE	INTERPRETATION	VISIBLE REACTION
1	Negative	Mixture remained liquid
2	Weak positive	Distinct precipitate
3	Distinct positive	Mixture thickened immediately

4.2.4.2 Somatic cell count (SCC) and procedure

Somatic cell count is a recognised indicator of a cow's health and milk quality. Milk SCC reflects the level of infection and resultant inflammation in the mammary gland of dairy cows, as associated with mastitis (Harmon, 1994). Milk from healthy udders exhibits SCC of less than 200,000 cell ml^{-1} of milk, while for cows with CM, the excretion of SCC is usually higher than 200,000 cell ml^{-1}. In milk with CM, for example, SCC can reach a few million cells per millilitre. Somatic cell count is also an indicator of milk quality, as shelf life is reduced in high-SCC milk and the processing quality and yield of some milk products is reduced when SCC rises (Tsenkova *et al*., 2001).

The SCC's for each quarter sampled were determined by the Nestlé Fresh Milk Laboratory using the Fossomatic machine (Fossomatic model 90, A/S N FOSS ELECTRIC ILLEROD DENMARK). A blind test was conducted to check whether the machine was functioning properly. Fresh samples must be at least 24 hours old (from sample taking) before measurement. The samples were heated to 40^0 C in a water bath in order to melt the butterfat. The heated samples were mixed carefully by gently turning them over a few times. A 500 *µl* fixed-volume pipette was filled with the sample (the pipette supplied with the instrument was used, and is recommended for use with the Fossomatic 90). The intake chamber was pressed down and the sample was dispensed into the chamber. The chamber was pressed down to initiate a measuring cycle indicated by the extinguishing of the green light. The first result in a series of measurements was displayed after approximately 48 seconds, indicated by a count on the green light display. The results displayed were multiplied by 1000 in order to give the result as the number of somatic cells per ml of sample. The accepted value of SCC at the Nestlé laboratory ranges from 0 to 400 000 cells per millilitre (Personal Communication, Nestlé Laboratory, 2004).

4.2.5 Milk composition analysis

The milk components fat, protein, lactose, and solids non-fat (SNF) were analysed using a Dairy Lab II automatic analyser at the Nestlé factory in Harrismith.

The samples were heated in a water bath with the thermostat set at $40^0C \pm 2^0C$. The Dairy Lab II machine was zeroed and a bottle containing clean distilled water was put under the pipette. Once the zero cycle was complete, “Enter” was pressed. The sample was gently mixed by flipping it over or stirring with a thermometer. The sample was put under the pipette and measured. The printer was fed with paper and switched on. At the end of the measuring cycle, the milk sample was removed from beneath the pipette and 0.1% Triton X 100 solution was placed under the pipette. The pipette was swung to a vertical position for the cleaning cycle to commence. At the end of the cleaning cycle the Dairy Lab II returned to standby mode. The sample was discarded after testing (Nestlé Laboratory Manual, 2004).

The TPC method consists of a bottom film coated with nutrients of standard methods agar (SMA) and a cold water-soluble gelling agent. Over this lies the flexible top film that is coated with the gelling agent and 2.3.5-triphenyl tetrazolium chloride indicator dye. The indicator stains the colonies red and facilitates counting. The grading standard for milk quality at Nestlé is as follows: Grade A is milk containing TPC ranging from 0-50 000 counts; normal-quality or grade B milk has 51-200 000 counts; and poor-quality or grade C milk has 201 000 counts or more.

The TPC plate was placed on a flat surface. The milk sample was diluted by adding 0.01ml of milk to 10ml Ringer solution. The top film was lifted and 1.0ml of the sample was inoculated onto the centre of the bottom film with a plate loop pipetting syringe. The top film was released onto the inoculum. The plastic spreader (recessed side down) was placed on the top film over the inoculum. The sample was distributed with a downward pressure on the centre of the plastic spreader. The spreader was removed and the plate was left undisturbed for one

minute to allow the gel to solidify. The plates were incubated at 32^0C for 72 hours. Colonies were counted and then multiplied by 1000 and reported as total plate count per millilitre (TPC/ml) (Houghtby *et al*., 1992).

4.2.6 Statistical analysis

Data was captured on a Microsoft Excel worksheet and subsequently analysed using the general linear model (GLM), univariate, and the frequency procedures of statistical analysis system (SAS, 1999). The actual SCC and TPC variables had a skewed distribution; hence they were transformed to natural logarithm (ln) forms prior to the application of statistical analysis. After the statistical analysis, the means and values were reported in actual measurements. The influence of some selected farmers' management practices, cleanliness scores, and some cow-intrinsic factors (level of daily milk yield, parity and breed) on the SCC, TPC and milk composition variables were tested using the GLM procedure. The daily milk yield was fitted as a covariance factor. The association between SCC, TPC and CMT variables and the milk composition variable was tested using Pearson correlation. Factor means were separated using the Tukey-Kramer procedure.

4.3 RESULTS AND DISCUSSION

The milk quality parameters studied were SCC, TPC, and CMT. The possible risk factors studied on the farms concerned were breed, parity, daily milk yield, udder and rear leg cleanliness, and milking area cleanliness scores.

The mean TPC was 1 X 10^3 and the milk of only 1.7% (2 cows) of the sampled cows was above standard for TPC (200.000/ml). The mean SCC was 172.5 X 10^3 cells/ml, and the milk of 21.7% of the sampled cows was above the South African regulatory standards for SCC (500 000 cells/ml). On QwaQwa dairy farms, 78.3% of the herds were in compliance with the SCC below 500 000 cells/ml.

4.3.1 Relationship between California mastitis test and somatic cell count

California mastitis test scores showed a significant relationship with SCC. Regression of SCC on CMT score showed that for every one unit increase in CMT score there was a corresponding increase of 6.0±1.1 cells/ml. The coefficient of determination for this regression was 71%. This is in accordance with the results of Shitandi & Kihumbu (2004), who found that infected udder quarters had significantly ($P<0.01$) higher mean values for both SCC and CMT.

4.3.2 Factors affecting somatic cell count, total plate count and California mastitis test

Somatic cell count CMT and TPC are influenced by many factors. In this study the aim was to determine the influence of different breeds, parity stages, daily milk yields, udder and rear leg cleanliness, and milking area cleanliness scores on SCC, CMT and TPC. Mean values obtained for SCC, TPC and CMT are presented in Table 4.2.

TABLE 4.2: Mean (±s.e) somatic cell count (SCC, cells/ml), total plate count (TPC, /ml) and California mastitis test (CMT, score) for breed, parity, udder and rear leg and milking area cleanliness (scores)

Factors		Variables		
	N	SCC (cells/ml) X 10^3	TPC (/ml) X 10^3	CMT (Score)
Breed		NS	NS	NS
Brahman	15	400.3±1.4[a]	1.9±1.6[a]	1.56±0.16[a]
Drakensberger	16	243±1.4[a]	5.4±1.6[a]	1.37±0.17[a]
Dairy Shorthorn	14	297±1.5[a]	1.3±1.7[a]	1.49±0.18[a]
Holstein-Friesland	50	268±1.3[a]	2.7±1.4[a]	1.50±0.11[a]
Jersey	16	199±1.4[a]	2.7±1.6[a]	1.34±015[a]
Mixed breeds	9	268±1.5[a]	2.7±1.8$_a$	1.53±0.19[a]
Parity		***	NS	***
1	27	147±1.3[a]	1.8±1.5[a]	1.2±0.14[a]
2	20	243±1.4[ab]	3.3±1.5[a]	1.4±0.15[ab]
3	27	297±1.3[ab]	2.7±1.5[a]	1.5±0.14[ab]
4+	46	400.3±1.3[ab]	2.7±1.8[a]	1.7±0.12[ab]
Daily milk yield		0.019±0.023NS	0.028±0.031NS	0.004±0.01NS
Udder and rear leg		NS	NS	NS
Clean	97	243±1.2[a]	3.6±1.2[a]	1.4±0.06[a]
Slightly dirty	18	328±1.3[a]	4.4±1.5[a]	1.6±0.14[a]
Heavily soiled	5	243±1.7[a]	1.2±2.1[a]	1.4±0.26[a]
Milking area		NS	NS	NS
Clean	44	243±1.3[a]	2.2±1.4[a]	1.5±0.13[a]
Slightly dirty	44	268±1.3[a]	1.8±1.5[a]	1.4±0.13[a]
Heavily soiled	32	297±1.3[a]	4.9±1.5[a]	1.5±0.12[a]

NS = Not significant; ***, P<0.01; a factor means within a column with common superscripts do not differ (P>0.05).

Breed had no influence on SCC and CMT scores (P>0.05). The SCC ranged from 198.8±1.4 (cell/ml) for the Jersey to 400.3±1.4 (cell/ml) for the Brahman breed (Table 4.2). These results are supported by Du Preez's (2000) statement that there is a slight difference in the SCCs of the normal milk of different breeds of cows. Breed had also no influence on TPC (P>0.05).

Cow parity had a significant influence on SCC and CMT scores. Both SCC and CMT increased (P<0.01) from 147.3±1.3 cell/ml and 1.2±0.14 points in the first parity to 400.3±1.3 cell/ml and 1.7±0.12 points in the fourth parity (Table 4.2). Therefore the increasing SCC with an advance in parity is in agreement with a recent finding by Kerro & Tareke (2003) that the risks of mastitis increase

significantly with the advancing age of the cow, which approximates to the parity number. Also, the results of this study are supported by a study of the factors affecting milk SCC, conducted by Kiiman & Saveli (2000), who reported that milk SCC increases with increasing numbers of lactations. In the first lactation SCC was $285X10^3$, whereas in the second, third and fourth lactations the SCC was $321X10^3$, $461X10^3$ and $477X10^3$ respectively.

Daily milk yield had no influence on SCC, TPC and CMT (Table 4.2).

There was a non-significant (P>0.01) difference between clean udders and rear legs and slightly dirty udders and rear legs when it came to SCC (243±1.2; 328±1.3), TPC (3.6±1.2; 4.4±1.5) and CMT scores (1.4±0.06; 4.6±0.14). McKinnon *et al*., (1983) found that milk from heavily soiled, unclean udders contains high total bacterial counts with more than 10 000 cfu/ml. In this study the udder and rear leg cleanliness had no significant influence on TPC. In addition, udder and rear leg cleanliness had no influence on SCC and CMT scores (P>0.05). It had been expected that dirty udders and lack of rear leg cleanliness would lead to a high SCC due to the potential exposure of cows to infective bacteria.

There was also a non-significant (P>0.01) SCC difference in clean, slightly dirty and heavily soiled milking areas (243±1.3; 268±1.3 and 297±1.3 respectively). There was a difference in TPC between clean (2.2±1.4) and heavily soiled (4.9±1.5) milking areas, but the difference was not significant. Milking area cleanliness scores also did not have influence on SCC, TPC and CMT scores (P>0.05). The SCC was higher (297±1.3) for heavily soiled milking area compared to clean area (243±1.3); however, the difference was not significant.

4.3.3 Influence of dairy farmer's management and hygiene factors on SCC, TPC and CMT

In this study, the availability of a separate calving area, hand washing, teat cleaning, and milking area disinfection were considered to be among the main risk factors, as failure to adhere to these factors predisposes cows to mastitis.

This study investigated the influence of these factors on CMT scores, SCC levels, and TPC.

On investigating the effect of having or not having a separate calving area for cows, the statistical test revealed non-significant differences to CMT scores, SCC levels and TPC (Table 4.3).

TABLE 4.3: Mean and standard errors for somatic cell count (SCC, cells/ml), total plate count (TPC, /ml) and California mastitis test (CMT, score) for different management-related factors

Management-related factors	N	SCC(cell/ml) X 10^3	TPC (/ml) X 10^3	CMT (score)
Separate calving area		NS	NS	NS
Yes	72	442±1.5^a	4.0±1.7^a	1.8±0.18^a
No	48	362±1.4^a	2.2±1.6^a	1.7±0.15^a
Hand washing		NS	S	S
Yes	104	297±1.4^a	1.3±1.6^a	1.5±0.15^a
No	16	540±1.5^a	6.6±1.8^b	1.9±0.19^b
Teat cleaning		NS	NS	NS
Yes	104	389±1.3^a	4.4±1.5^a	1.7±0.13^a
No	16	438±1.6^a	1.8±1.8^a	1.8±0.20^a
Milking area disinfection		NS	NS	NS
Yes	76	400.3±1.4^a	2.4±1.6^a	1.7±0.17^a
No	44	400.3±1.5^a	3.6±1.7^a	1.9±0.18^a

NS=Not significant; S=Significant; a factor means within a column with common superscripts do not differ (P>0.05).

With regard to the effect of washing of hands (YES vs. NO) on CMT scores and TPC, the statistical test revealed a significant difference ($P < 0.05$). The SCC level was higher where farmers' never practised hand washing (540±1.5) compared to where farmers did practise hand washing (297±1.4).

The effect of teat cleaning was determined by comparing those farmers that did adhere to this practise with those who did not. The influence of teat cleaning vs. no teat cleaning on CMT, SCC and TPC was 1.7 vs. 1.8, 362 vs. 400.3, and 4.4 vs. 2.9 respectively. However, the statistical test showed no significant difference between the two practices, which is also in agreement with that reported by Knappstein *et al*., (2002).

Farmers who practised milking area disinfection had cows with low CMT scores, low SCC levels and low TPC compared to those who did not adhere to this practice; however, the difference was insignificant (P>0.05).

4.3.4 Management and animal-related factors affecting milk composition

Table 4.4 depicts the milk components (fat, protein, lactose and solids non-fat) for different animal-related and management factors. The overall average percentages of fat, protein, lactose and SNF measured were 4.41%, 3.40%, 4.87% and 8.66% respectively. The milk composition differs within species in dairy cows (Waldner *et al*., 2004). In this study, breed did not have an influence on milk components (P>0.05). Belcher *et al*., (1979) also found breed to have no influence on milk components. The fat content ranged from 3.9% for Drakensberger to 4.6% for Holstein-Friesland and mixed breeds. Protein content ranged from 3.2% for Holstein-Friesland to 3.4% for Brahman, Dairy Shorthorn and Jersey breeds. Lactose content ranged from 4.8% for Drakensberger and mixed breeds to 4.9% for Brahman, Dairy Shorthorn, Holstein-Friesland and Jersey breeds. Solids non-fat content ranged from 8.4% for Drakensberger to 8.8% for Dairy Shorthorn and Jersey breeds. The lack of influence by breed differences on milk components in this study might be attributed to sampling errors associated with the number of cows and other factors that were unaccounted for.

TABLE 4.4: Mean and standard errors of fat, protein, lactose and solids non-fat percentages for different animal related and management factors

Factors		Milk components			
	N	Fat (%)	Protein (%)	Lactose (%)	SNF (%)
Breed		NS	NS	NS	NS
Brahman	15	4.5±0.26[a]	3.4±0.1[a]	4.9±0.08[a]	8.7±0.17[a]
Drakensberger	16	3.9±0.28[a]	3.3±0.1[a]	4.8±0.08[a]	8.4±0.19[a]
Dairy Shorthorn	14	4.2±0.29[a]	3.4±0.12[a]	4.9±0.09[a]	8.8±0.19[a]
Holstein-Friesland	50	4.6±0.19[a]	3.2±0.07[a]	4.9±0.06[a]	8.7±0.13[a]
Jersey	16	4.3±0.24[a]	3.4±0.1[a]	4.9±0.08[a]	8.8±0.16[a]
Mixed breeds	9	4.6±0.31[a]	3.3±0.13[a]	4.8±0.09[a]	8.5±0.21[a]
Parity		NS	NS	NS	NS
1	27	4.1±0.23[a]	3.3±0.09[a]	4.9±0.07[a]	8.7±0.16[a]
2	20	4.6±0.24[a]	3.3±0.09[a]	4.8±0.07[a]	8.6±0.16[a]
3	27	4.4±0.22[a]	3.4±0.09[a]	4.9±0.07[a]	8.8±0.15[a]
4	46	4.5±0.19[a]	3.4±0.08[a]	4.8±0.06[a]	8.6±0.13[a]
Udder and rear leg		NS	NS	NS	NS
Clean	97	4.4±0.1[a]	3.4±0.04[a]	4.8±0.03[a]	8.6±0.07[a]
Slightly dirty	18	4.3±0.2[a]	3.4±0.09[a]	4.9±0.07[a]	8.8±0.15[a]
Heavily soiled	5	4.5±0.4[a]	3.2±0.17[a]	4.9±0.13[a]	8.6±0.28[a]
Milking area		NS	NS	NS	NS
Clean	44	4.4±0.2[a]	3.4±0.08[a]	4.9±0.06[a]	8.7±0.14[a]
Slightly dirty	44	4.2±0.21[a]	3.4±0.09[a]	4.9±0.07[a]	8.3±0.14[a]
Heavily soiled	32	4.4±0.19[a]	3.2±0.08[a]	4.8±0.06[a]	8.5±0.13[a]

NS = Not significant; a factor means within a column with common superscripts do not differ (P>0.05).

Parity had no influence on milk components (P>0.05). In concurrence with this finding Sevi *et al*., (1999) and Wohlt *et al*., (1981) also found parity to have no influence on ewe milk constituents. It can be speculated that this, as in the study of Sevi *et al*. (1999), might be attributable to other factors such as feeding, number of calves suckled, management practices, and climatic conditions – all of which play a role when different parities are compared. Mondragon *et al*., (1983) also found that parity had no effect on milk composition in beef cattle – a genuine possibility in this study, because some of the sampled cows were dual-purpose breeds.

Udder, rear leg and milking area cleanliness also had no influence on milk components (P>0.05).

4.3.5 Correlation between SCC, TPC, CMT and milk composition variables

Table 4.5 presents the correlation coefficients between SCC, TPC and CMT scores and milk components (fat, protein, lactose and SNF) and daily milk yield.

TABLE 4.5: Pearson correlation coefficients between milk yield and components with SCC, TPC and CMT

	Milk yield and Components				
	Fat	Protein	Lactose	SNF	Daily milk yield
SCC	0.22*	- 0.11^{ns}	- 0.41***	- 0.37***	0.18*
TPC	- 0.03^{ns}	- 0.05^{ns}	- 0.13^{ns}	- 0.21*	-0.11 ^{ns}
CMT	0.25**	- 0.22**	- 0.39***	- 0.39***	0.15 ^{ns}

*: P < 0.05; **: P < 0.01; ***: P< 0.001; ns: not significant

The correlation between SCC and fat percentage was weakly positive (r=0.22; P<0.01), while it was strong and negative with regard to lactose (r=-0.41; P<0.001) and SNF percentage (r=-0.37; P<0.001). A similar correlation pattern was also observed between CMT and milk components (Table 4.5). Fat concentration may be reduced in milk presenting a high SCC due to the decrease in fat synthesis by epithelial cells of the mammary gland (Randolph & Erwin, 1974; Schultz, 1977). However, some studies have indicated that the correlation between SCC and fat percentage may be negative, positive or null (Schultz, 1977; Munro *et al*., 1984; Pereira *et al*., 1999).

Several studies have reported a decrease in lactose concentration in the milk of cows with a high SCC. A negative correlation (r=-0.41; p<0.001) was observed between the percentage of lactose in milk and the SCC. This is supported by the statements of Miller *et al*., (1983) who reported that mastitis determines a continuous reduction in lactose concentration in milk with an SCC above 100 000

cells/ml. Klei *et al*., (1998) also demonstrated that when SCC rises from 83 000 cells/ml to 870.000 cells/ml, lactose concentration is reduced from 4.98% to 4.71%. Results reported by Fernandes *et al*., (2004) indicate that lactose content decreases progressively with an increase in SCC, with values ranging from 4.56% to 4.36% when SCC levels were at 143.000 and 550.000 cell/ml respectively. A highly negative correlation ($P<0.001$) was observed between SCC and lactose content and between SCC and SNF content. A negative correlation of SCC and lactose is in accordance with the results of several studies (Auldist *et al*., 1995; Klei *et al*., 1998; Fernandes *et al*., 2004). A reduction in lactose content in milk with a high SCC, according to Shuster *et al*., (1991), may be due to the passage of lactose from milk into the blood.

The protein content of the milk did not show a significant correlation ($P>0.05$) with SCC levels, which is in agreement with results reported by Fernandes *et al*. (2004). According to these researchers experimental results are not clear in relation to the effects of high-SCC milk on the concentration of total protein content.

Daily milk yield was correlated with SCC ($r=0.18$, $P<0.05$). Kennedy *et al*., (1982) reported a correlation of 0.14 between milk yield and SCC, while Emanuelson *et al*., (1988) found a higher correlation of 0.46.

Sargeant *et al*., (1998) reported a negative correlation between SCC and the production of milk, fat, lactose and casein. In this study only, lactose and SNF negatively and significantly correlated with SCC. Total plate count showed a weak association with milk components, and the correlation was negative and significant only with SNF ($r=-0.21$; $P<0.05$).

4.4 CONCLUSIONS

Most of the factors studied (breed, daily milk yield, and udder, rear leg and milking area cleanliness) did not have an influence on SCC, TPC or CMT scores.

There was a strong relationship between SCC and CMT, which suggests that the CMT may be a useful indicator, since it can provide the diagnostic reliability to detect SCM, as well as a reliable prediction of SCC. Therefore CMT can be used as the method of choice for farmers when it comes to detecting sub-clinical mastitis.

Management factors (separate calving area, teat cleaning, and milking area disinfection) did not have an influence on SCC, TPC or CMT scores. However, farmers who practised hand washing every time before milking ensured a lower TPC count and CMT score. All management and animal-related factors (breed, parity, daily milk yield, and udder, rear leg and milking area cleanliness) did not have an influence on milk components (fat, protein, lactose and SNF). The lack of influence of farm management and animal-related factors on milk composition in this study could be attributed to sampling errors.

The results of this study point to a significant decrease in lactose and SNF content under the influence of SCC, as well as a non-statistically significant increase in the protein content of milk with a high SCC. In milk with a high SCC, a lower fat content was detected.

The SCC of individual cow's milk showed a strong negative correlation with lactose and solids non-fat (SNF). Although the evidence generated by this study may not be as strong as reported in other studies, the general trend of a negative effect of high SCC and TPC on milk yield and milk composition suggests that better control of mastitis on farms would allow farmers to produce milk of a higher quality and generate a better income from dairy farming.

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CHAPTER 5

GENERAL CONCLUSION AND RECOMMENDATIONS

5.1 GENERAL CONCLUSIONS

The dairy cows in the QwaQwa area contribute a significant amount to the daily welfare of the very poor. They are often kept for one type of production only, for example milk production. Holstein-Friesland is the breed most commonly kept in QwaQwa. Dairy production in QwaQwa is dominated by small-scale farming. About 31.7% of marketed milk in QwaQwa is sold to consumers through informal milk markets, despite policies that discourage this practice. The farmers in QwaQwa are usually subsistence farmers with small land holdings (58 to 5084 ha) and a very small herd size (0 to 50 animals).

A major obstacle to progress in improving animal production among small-scale dairy farmers is illiteracy and the low level of education. QwaQwa farmers have limited access to information or knowledge regarding effective mastitis management amongst cows. Mastitis, especially sub-clinical mastitis, is a problem that seems to go unnoticed by farmers. Diagnosis is almost non-existent due to a lack of the necessary kits (CMT), and since many small-scale dairy farmers in QwaQwa are resource poor, they opt to use their hands to detect sub-clinical mastitis infection. Only 10.7% have CMT kits, with the remainder having no such facilities. The farmers are also unable to take their milk to diagnostic laboratories due to a lack of knowledge and transportation, as well as the high costs involved.

Milk and dairy products are highly perishable. Hygiene levels on farms in QwaQwa are considered unsatisfactory due to poor teat cleaning and drying style, as the majority of farmers (81.6%) use a bucket of water and shared towel for this purpose. This was also confirmed in the survey, which revealed that 95% of the farmers did not practice teat disinfection before or after every milking, and 36.7% of the farmers did not test the first strip of milk during milking. A number of farmers (16.7%) did not clean the teats before milking. Fifty-three percent of the farmers never cleaned or disinfected their milking areas. This is reason for concern, since a lack of hygiene on a farm can result in bacterial contamination. In addition, only 8.3% of farmers kept records. Control of mastitis requires a sound understanding of its causes and of management techniques that limit the

spread of infection. Since dairy farmers often lack knowledge, they need help from dairy scientists, extension officers, educators and veterinarians. It is therefore important that such scientists have adequate knowledge about mastitis control.

5.2 GENERAL RECOMMENDATIONS

This study gives rise to the following recommendations:

5.2.1 Milking and general hygiene practices

- Small-scale dairy farmers need to receive training on correct or good hygiene management.
- Farmers must be educated in the control of the spread of mastitis through, for example, the use of a separate paper towel on each milking cow instead of using shared towels.
- Farmers should attempt to improve hygienic standards through the use of post-milking teat disinfection or dipping (PMTD) using iodine solutions, as well as the use of detergents like soap, which can be cheaply acquired.
- Farmers could also apply milking salves to teats before and after every milking to reduce teat abrasion.
- The lack of the required diagnostic kits (CMT) should be addressed.

5.2.2 Livestock improvement and veterinary extension

- Farmers should be educated on ideal dairy production practices by means of advice on the adjustment of management practices.
- A platform for information dissemination should be provided through the establishment of animal health centres, and/or this information

could be conveyed to farmers during information days, at multipurpose community centres, etc.

Further research is needed to identify the needs of the small-scale dairy farmers as far as management practices are concerned, and to come forward with effective mastitis control programmes.

QUESTIONNAIRE ON THE EFFECT OF THE MANAGEMENT OF MASTITIS INCIDENCE IN DAIRY COWS IN QWAQWA

Compiled by L.K. TAOANA

NIVEMBER 2004

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General objectives of the questionnaire:

- **To gather information about the farm and its management**
- **To test the farmer's knowledge of mastitis disease**

NB: ***Anything you tell will be kept strictly confidential***

APPENDIX 1

QUESTIONNAIRE ON THE EFFECT OF THE MANAGEMENT OF MASTITIS INCIDENCE IN DAIRY COWS IN QWAQWA

Codes for office use

INTERVIEWER:_____

DATE:_____

1. PERSONAL

1.1 FARMER'S NAME:_____ ☐

1.2 FARM NAME:_____ ☐

1.3 AGE:_____ ☐☐

1.4 MARITAL STATUS:_____

1) Married 2) Single 3) Widowed ☐

4) Divorced

1.5 GENDER (F/M):_____ ☐

1.6 NUMBER OF DEPENDANTS

1) Children_____ ☐☐

2) Others_____ ☐☐

1.7 Education

1) No education

2) Grade 1 to 7

3) Grade 10 to 12

4) College or university education in agriculture

Codes for Office use

2. DAIRY HERD AND FACILITIES

2.1 How large is your total farm area (in ha)? ☐☐☐☐

2.2 Size of the grazing area (ha) ☐☐☐☐

2.3 How long have you been farming with dairy animals (in years)?_____ ☐☐

2.4 Do you stay on the farm:_____ ☐

2.5 Number of people hired and working on the dairy Farm_____ ☐

2.6 How many dairy cattle do you own?

2.6.1 In total_____ ☐☐☐

2.6.2 Milking cows_____ ☐☐☐

2.6.3 Dry cow_____ ☐☐

2.6.4 Heifers_____ ☐☐

2.6.5 Calves (male and female up to 1 year of age)_____ ☐☐

2.6.6 Bulls_____ ☐☐

2.7 What type of milking method do you use? ☐

1) Hand milking 2) Machine milking

2.8 Into which category does your milk production fall?

1) Less than 25 litres (l)

2) Between 25 l and 50 l

3) Greater than 50 l and less than 75 l

4) Greater than 75 l and less than 100 l

5) Greater than 100 l and less than 500 l

6) Greater than 500 l ☐

2.9 Do you sell milk?

1) Yes 2) No ☐

Codes for Office use

2.10 I f your answer to 2.9 is YES, to whom do you sell?

1) To neighbours

2) To local vendors

3) To milk-processing companies

4) Others (specify) ☐

2.11 If you sell your milk to local vendors, do you sell pasteurise before selling (question to be asked to those not selling milk to milk-processing companies

1) YES 2) NO ☐

2.12 Do you have any other livestock enterprise on the same Premises (other than dairy)?

1) YES 2) NO ☐

2.12.1 If YES to Q 2.12, PLEASE describe (list):

_____

_____

_____ ☐

3. <u>MASTITIS KNOWLEDGE</u>

3.1 Do you know what mastitis is?

1) YES 2) NO ☐

3.2 What is the local name for mastitis?

_____

3.3 Do you notice the changes in the milk (e.g. flakes, clots, serum and blood)?

1) YES 2) NO ☐

Codes for Office use

3.4 Do you notice the changes in the cow (e.g. fever and reduced appetite)? ☐

3.5 I s mastitis a new phenomenon on your farm?

1) YES 2) NO ☐

3.5.1 If YES to Q. 3.5, when did you first see it?

_____ ☐

3.6 Do you regard mastitis as a priority disease on your farm?

1) YES 2) NO ☐

3.7 How many cases do you see per year?

_____ ☐☐

3.8 What types of cows are frequently affected by mastitis? e.g.

1) Low milk producers
2) Medium milk producers
3) High milk producers ☐

3.9 How often do you observe mastitis problems on your farm?

1) Always
2) Sometimes
3) Never ☐

3.10 Do you test for mastitis before milking?

1) Always
2) Sometimes
3) Never ☐

Codes for Office use

3.11 What do you use to test for mastitis? (PLEASE, describe and show)

_____

_____

_____ ☐

4. <u>COWS AND MILKING MANAGEMENT</u>

4.1 Do your milking cows graze?

1) YES 2) NO ☐

4.2 Have you noticed any teat injury problems associated with grazing conditions (such as from shrubs, glass, metal objects, etc.)?

1) YES 2) NO ☐

4.3 How often do you rate your grazing (veld) suitability for dairy cows in terms of factors causing teat injury?

1) Very good

2) Average

3) Poor ☐

4.4 Where do you keep your dairy animals?

1) In a separately constructed dairy barn

2) In open enclosures (cattle kraals)

3) Other (specify) ☐

4.5 How would you describe your milking-cow barn?

1) Most often wet and muddy

2) Sometimes wet and muddy

3) seasonally (rainy period) wet and muddy

4) Always dry and clean ☐

Codes for Office use

4.6 How often do you clean the milking-cow barn?

1) Once per day

2) Twice per week

3) Once per week

4) Describe any other frequency of cleaning

_____ ☐

4.7 Does your cow barn have proper ventilation and dry bedding?

1) YES 2) NO ☐

4.8 Do you have a separate calving/maternity pen?

1) YES 2) NO ☐

4.9 Do you have a separate milking area?

1) YES 2) NO ☐

4.10 Do you disinfect your milking area? ☐

1) YES 2) NO

4.11 How often do you clean and disinfect your milking area?

1) After every milking

2) Once per day

3) Twice per week

4) Once per week

5) Describe any other frequency_____ ☐

4.12 How many times do you milk each cow per day?_____ ☐

4.13 Who does the milking?

1) Self or family member

2) Worker

3) Other (specify)

Codes for Office use

4.14 Do you keep to a punctual milking time?

1) YES 2) NO ☐

4.14.1 I f your answer to Q.4.14 is NO, why not?

_____

_____

_____ ☐

4.15 Is the milk yield of each cow consistent from day to day?

1) YES 2) NO ☐

4.16 During milking time do you concentrate totally on the milking-cow or do you combine it with other work?

1) YES 2) NO ☐

4.17 Do you wash your hands (with soap) before milking?

1) Always

2) Sometimes

3) Never ☐

4.18 Do you clean the teats before and after every milking?

1) YES 2) NO ☐

4.19 Do you disinfect teats before and after every milking?

1) YES 2) NO ☐

Codes for Office use

4.20 What do you use to dry off washed teats before milking?

1) Never practice teat washing and drying

2) Use bucket of water and one towel for all cows

3) Dry each cow with its own towel

4) Other (specify)_____

_____

_____ ☐

4.21 Do you remove the foremilk and observe for any signs of mastitis?

1) YES 2) NO ☐

4.22 Do you strip milk onto the floor?

1) YES 2) NO ☐

4.23 When you see mastitis in some of your cows, do you separate them from the others?

1) YES 2) NO ☐

4.24 Do you feed your cows during milking time?

1) YES 2) NO ☐

4.25 Describe your milking practices for mastitis-affected cows?

_____

_____

_____

_____ ☐

4.26 In which month(s) do you see most mastitis cases?_____ ☐

Codes for Office use

4.27 Who treats your mastitis cows?

1) Self or family member

2) Veterinarian

3) Animal health technician

4) Other (specify) ☐

4.28 Do you record all cases of mastitis?

1) YES 2) NO ☐

4.29 Do you keep records of treatment given and cost of treatment?

1 YES 2) NO

4.30 How much would be your mastitis treatment costs be compared to the cost of other diseases on your farm (in percent)?

1) Negligible (no cost)

2) 10-30%

3) 31-50%

4) 51-70%

5) 71-90%

6) 91-100% ☐

4.31 Do you buy cows for your dairy herd?

1) YES 2) NO

4.31.1 If YES to Q. 4.31, do you make sure that the cows you are buying are mastitis free?

1) YES 2) NO ☐

Codes for Office use

4.32 What measures do you take when you see cows with severe mastitis on your farm?

1) Cull or sell them

2) Never experienced or take no action

3) Treatment by animal health technician or veterinarian

4) Don't know ☐

4.33 What is the average drying period you allow the milking--cows at the end of their lactation period?

1) One month or less

2) Two months

3) Three months or more ☐

4.34 Have you ever treated cows for mastitis when they are dried off? ☐

1) YES 2) NO

4.35 In your opinion what are the major factors that predispose cows to mastitis?

_____ ☐

_____

4.36 In your opinion what would be the best solution to maximise mastitis cases in dairy farms?

_____ ☐

_____

4.37 Would you be interested in being involved in future research projects on mastitis? ☐

1) YES 2) NO

THANK YOU SO MUCH FOR YOUR TIME!

APPENDIX 2

Data collection sheet for somatic cell count and visual udder health assessment

Cow id	Farm owner name	Approximate or measured daily milk yield	Approximate or exact date for this calving	Cow age (in year)	Current parity	Breed type	Visual udder score for mastitis[1]	Udder and rear leg cleanliness score[2]	Somatic cell count

[1]1) Normal, 2) One teat with visible mastitis symptom and 3) two or more teats with visible mastitis symptom

[2]Clean heavily soiled with dung and dirty

1 → 2 → 3

APPENDIX 3

SCORING SHEET FOR CALIFORNIA MASTITIS TEST

COW ID	FARM OWNER'S NAME	VISIBLE REACTION FOR COW'S MILK (Scores: 1, 2 and 3)				
		LR	RR	LF	RF	REMARKS ON UDDER QUARTES

Description of udder quarters: LR = left rear; RR = right rear; LF = left front; RF = right front

Score:
1. **Negative (no precipitation)**
2. **Weak positive (distinct precipitation)**
3. **Strong positive (a gel is formed)**