

SURVEY OF COLOSTRUM QUALITY AND MANAGEMENT PRACTICES ON
COMMERCIAL DAIRY FARMS IN THE EASTERN CAPE PROVINCE OF
SOUTH AFRICA

by

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DECLARATION

Student number: **4117-773-8 (WS Schoombee)**

I declare that besides the assistance I received from Dr. Florence V. Nherera from the ARC, Irene, Pretoria, with data analysis, the dissertation entitled **“Survey of colostrum quality and management practices on commercial dairy farms in the Eastern Cape Province of South Africa”** is my own work and that all the sources that I have used or quoted have been indicated and/or acknowledged by means of complete references.

SIGNATURE

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15 August 2011

DATE

DEDICATION

I dedicate this work to my father, Wilhelm Schoombee, for teaching me persistence, encouraging me to never quit and to always pursue my goals; to my mother, Viona Schoombee, for teaching me the values that I live by and the value of empowering myself with knowledge; to my wife, Christa, for her unconditional support in all that I do and to my two sons, Barry and Chris; May this work inspire you to always aim high and live your dreams.

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ABBREVIATIONS

| | | |
|-----|----------------|--|
| 1. | AEA | Apparent efficiency of IgG absorption |
| 2. | BCS | Body condition score |
| 3. | BW | Body weight |
| 4. | CIL | Colostrum Immunoglobulin Level |
| 5. | CIT | Colostrum Immunoglobulin Transference |
| 6. | CR1 | Initial (1 st) colostrometer reading taken, immediately after collection at various temperatures |
| 7. | CR2 | Second (2 nd) colostrometer reading taken after the sample was allowed to cool down to room temperature (20°C) |
| 8. | CR3 | Third (3 rd) colostrometer reading taken 21 days post collection after the sample was allowed to naturally thaw to 20°C after being frozen |
| 9. | E. coli | Escherichia coli |
| 10. | ELISA | Enzyme Linked Immunosorbent assay |
| 11. | FPT | Failure of passive transfer of immunity |
| 12. | g | gram |
| 13. | GIT | Gastrointestinal tract |
| 14. | hr | hour |
| 15. | hrs | hours |
| 16. | Ig | Immunoglobulin |
| 17. | IgG | Immunoglobulin (type G) |
| 18. | L | Litre |
| 19. | MEC | Mammary epithelial cells |
| 20. | mg | milligram |
| 21. | ml | millilitre |
| 22. | NAHMS | National Animal Health Monitoring System |
| 23. | Reg1 | Regression estimate value 1 |
| 24. | Reg2 | Regression estimate value 2 |
| 25. | Reg3 | Regression estimate value 3 |
| 26. | RIA | Radial Immunodiffusion Assay |
| 27. | sIgA | Secretory form of IgA |
| 28. | SG | Specific Gravity |

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ABSTRACT

Bovine maternal antibodies are not transferred across the placenta during pregnancy and newborn calves are unable to produce their own antibodies within the first weeks after birth. As neonates are born agammaglobulinemic they need to acquire immunoglobulins (Ig) from their dam's colostrum to acquire passive immunity. Colostrum fed to dairy calves, which is not timeous, of inadequate quantity and of unverified quality, might result in decreased neonate health.

The aim of this study was to conduct a survey of the management of colostrum on commercial dairy farms, to estimate the quality of the Ig titre of colostrum fed to neonates and finally to recommend methods and techniques critical to the successful management of colostrum.

The methods used included a questionnaire which was conducted as a structured interview on a one-on-one basis among 50 randomly selected commercial dairy farmers in the Eastern Cape Coastal Region of South Africa. The estimation of the colostrum Ig titre of colostrum fed to neonates was made by the on-farm measurement of specific gravity (SG) by making use of a commercially available KRUUSE colostrometer (Fleenor and Stott, 1980). A pooled colostrum sample, from each of the four quarters, from 90 randomly selected post-partum cows was collected on a leader commercial dairy farm. This method was used to compare colostrum samples from cows run under similar management practices. These samples were collected for analysis within 6 hrs of calving and were done over 3 seasons (autumn, winter and spring).

Survey - The colostrum mass and timing of the initial feed are the most important factors when aiming to achieve adequate passive immunity. The results of the survey indicated that most of the farmers of this region feed an inadequate mass of colostrum (volume and Ig concentration) and only 52% of farmers surveyed feed colostrum less than 6 hrs post-partum. The majority (78%) of surveyed farmers did not follow up their initial colostrum feeding.

Colostrum sampling - At the trial site only 10% (9 from 90 colostrum samples measured), were found to be of adequate SG quality. Cow age (parity), season of calving and colostrum temperature had an influence on the estimated colostrum SG. However, season of calving was found to have the greatest influence on SG values. These results were consistent with findings from previous studies that SG values from the cooler months were higher than those of the hotter months. Tables 4.7 (P=0.330), 4.8 (P=0.012) and 4.9 (P=0.005) showed that regression analysis confirmed that LS means across seasons were inadequately below the required 50 mg/ml Ig required for sufficient passive immunity. Tables 4.1 (P=0.164), 4.2 (P=0.011) and 4.3 (P=0.021) shows that season of calving had a much greater effect on CR than did parity, Table 4.5 (P=0.177). Table 4.4 shows that colostrum temperature has a significant effect on SG value.

Recommendations for methods and techniques critical to the successful management of colostrum were made. These recommendations were based on the analysis of the data obtained from the questionnaire and the on-farm colostrum sampling study.

The most important and critical management practices surveyed includes the timing of the cow and calf separation where it was found that only 30 from the 50 (60%) of the farms surveyed separate calves and dams at day (0), 19 from 50 farms (38%) separate at day (3-5) and 1 from 50 farms (2%) separate only at day 7 or later. Thus 40% of surveyed farms allow cows to nurse their calves. With regards to early exposure to pathogens this is a high risk management practice. Further to that, only 2 from 50 surveyed farms (4%) measure the colostrum quality fed to their calves and 48 from 50 farms (96%) feed colostrum of unmeasured quality. The mass of colostrum fed to calves is an important parameter for successful transmission of Ig. In the survey it was found that 28 from 50 farms (56%) feed 2L – 4L of colostrum and 11 from 50 farms (22%) feed 2L of colostrum. Thus 78% of farms feed approximately 50% of the amount of colostrum required for successful transmission of Ig. Finally only 1 from 50 farms (2%) freeze excess colostrum and 1 from 50 farms (2%) pool excess colostrum. Both these farms measure colostrum quality by colostrometer.

Key words: Colostrum, colostrometer, quality, management, survey, passive immunity, Failure of passive transfer of immunity (FPT).

CHAPTER 1

BACKGROUND

Immunoglobulins (antibodies) belong to a specialized class of serum protein and are produced after body exposure to antigens. Low blood immunoglobulin (Ig) concentration, or titre, noted soon after birth is linked to neonatal disease, morbidity and early mortality in the first days or weeks post-partum. These conditions have all been linked to the lack of, or supply of poor quality and/or quantity of colostrum fed to dairy calves within the first 24 hours post-partum (Besser and Gay, 1994; Arthington *et al.*, 2000).

Immunity is defined as the body's ability to recognize and dispose of substances which it interprets as foreign and harmful to its wellbeing (Blood *et al.*, 2007). Immunity is classified as active immunity derived from the calf's own body or passive immunity which is received from an outside source such as colostrum. A calf obtains maternal (passive) immunity by oral consumption of colostrum. Passive immunity is achieved when immunoglobulins (Ig) are transferred from a donor in which it was produced to a recipient via intestinal absorption to systemic circulation for the purpose of temporary immunity (Bush *et al.* 1971; Quigley, 2002; Blood *et al.*, 2007).

Maternal antibodies are not transferred across the placenta during pregnancy and newborn calves are unable to produce their own antibodies within the first weeks after birth (Corbett, 1991; Quigley and Drewry, 1998; Weaver *et al.*, 2000). Neonates, therefore, need to acquire immunoglobulins from their dam's colostrum (maternal immunity). Colostrum needs to be of high quality to successfully transmit passive immunity to the calf.

Colostrum specific gravity (SG) is indicative of colostrum quality (Morin *et al.* 2001). This is the ratio of the density of a substance i.e. colostrum, to the density of a reference substance i.e. water and is a dimensionless quantity. The SG of the reference (water) is equal to 1 if measured at the same temperature i.e. 20°C in the case of colostrum.

The time period from birth to first colostrum meal and the mass of colostrum Ig (a function of the amount of colostrum ingested and the Ig concentration/titre thereof) are the two most important factors contributing to calf health (Corbett, 1991; Pritchett *et al.*, 1991, Weaver

et al., 2000). However, the quantity of transferred immunoglobulin is dependent on well documented factors such as environmental conditions, breed, cow health, nutrition, parity, calving season and colostrum temperature.

Colostrum is a concentration of essential proteins known as immunoglobulins (Ig). These Ig are large molecules. The importance of early colostral Ig absorption by the neonatal calf for adequate passive immunity is well documented (Butler, 1983; Kruse, 1970(b); Morin *et al.*, 1997). Newborn calves rapidly absorb antibodies through the intestinal wall but soon lose this ability and Ig is then digested as normal proteins without the benefit of immunization (Schingoethe, 2001). Immunoglobulins are absorbed via a process known as pinocytosis by specialized cells in the lower small intestine. At about 12hrs post-partum these cells are replaced by basal nuclei incapable of pinocytosis. This absorption of Ig for passive immunity must occur before the calf's intestines become impermeable to the large Ig proteins. Gut closure or impermeability occurs about 12-24 hours post-partum and was defined by Lecce and Morgan in 1962 as being "the cessation of absorption of macromolecules from gut to blood in neonates". Immunoglobulins that are not absorbed assist in protecting the GIT (Radostis *et al.*, 2000).

Wells *et al.* in 1996 estimated that as much as 31% of calf mortality occurring within the first 3 weeks post-partum could be attributed to "Failure of Passive Transfer" (FPT). In 1993 the National Animal Health Monitoring System conducted a study to determine the serum levels of IgG in newborn calves in the United States of America. Of 2,177 calves tested from 598 farms, more than 40% experienced FPT (NAHMS, 2002). In addition, field and feeding trials confirmed that FPT is markedly reduced in calves who received 7.5%-10% colostral volume of their own bodyweight within 12 hours post-partum. FPT in dairy replacement calves has been linked to increased neonatal morbidity and mortality and long-term decreases in productivity. (Rice and Rogers, 1990; Arthington, 2001; Trotz-Williams *et al.*, 2008; Beam *et al.*, 2009). This demonstrates the importance of monitoring colostrum quality for the purpose of optimizing passive immunity (Quigley and Drewry, 1998; Arthington, 2001; Saucedo-Quintero *et al.*, 2004; Trotz-Williams *et al.*, 2008).

Failure to transmit passive immunity (FPT) may occur due to various reasons, any of which are not in the best interest of the newborn calf. A strong correlation exists between FPT and calf illness and early mortality and morbidity (Arthington, 2001). Even without illness, individual calves with FPT shed pathogens and contaminate the environment. The only

defence against FPT is good colostrum management practice. In dairy production, interventions are necessary to ensure ingestion of colostrum in order to achieve adequate and protective serum levels of passive immunity. It is, therefore, necessary to develop procedures ensuring adequate intake of colostrum for Ig transmission to achieve Ig blood levels of >10 g Ig/L. To achieve this at least 200 g of Ig should be consumed within the first 24 hours post-partum. Blood serum levels of <5 g Ig/L are indicative of FPT. The indiscriminate collection and pooling of fresh, whole colostrum without prior determination of its immunologic properties may lead to the storage and feeding of colostrum of unconfirmed quality (Tyler *et al.*, 1999; Kehoe *et al.*, 2007). Literature evidence (Donovan *et al.*, 1998; NAHMS 1993; NAHMS 2002), supports the problem statement that: Colostrum fed to dairy calves which is not timeous, of inadequate quantity and of questionable/unconfirmed quality might result in decreased neonate health.

From the above, it can be concluded that farm management practices may affect the concentration of immune components in colostrum and/or milk (Stelwagen *et al.*, 2009). This study hypothesises that the quality of colostrum fed to dairy calves on the trial site and the colostrum management of the 50 assessed commercial dairy farms in the trial area is inadequate. This research project was aimed at assessing the quality of colostrum fed to dairy calves at the trial site as well as obtaining data regarding common practices with regard to colostrum management on 50 identified commercial dairy farms.

Several contributing factors have been associated with the efficiency of passive immunity acquired by the newborn calf. These factors include, but are not limited to:

1. Age of calf at the initial feed (timing of the first colostrum feed) as the mechanism of pinocytosis (process during which Ig is absorbed by the GIT) diminishes gradually from 12-24hrs post-partum (Kruse, 1970 (a) & (b); Stott *et al.*, 1979; Bush and Stanley, 1980).
2. Mass of colostrum ingested during the first 24hrs of life. The smaller the mass the lower the colostral Ig levels (CIL) (Radostis *et al.*, 2000; Ghetie and Ward, 2000).
3. Concentration of IgG in the initial feed (colostrum quality). The lower the concentration the poorer the colostral immunoglobulin transference (CIT) (Radostis *et al.*, 2000; Ghetie and Ward, 2000).
4. The degree of selectivity exerted by the intestinal epithelium (Weaver *et al.*, 2008).

The major objectives of this study were:

1. To conduct a questionnaire survey to determine methods used for management of colostrum i.e. timing of the first colostrum meal, quantity of colostrum fed, frequency of colostrum meals, colostrum feeding methods and the timing of calf separation from the dam.
2. To estimate the immunoglobulin (Ig) concentration of colostrum fed to neonates by on-farm measurement of Ig specific gravity (SG) using a commercially available KRUUSE colostrometer.
3. To determine from post-partum cows, the effect of cow age, season and temperature of colostrum on colostrum SG and then quality.
4. To recommend methods and techniques critical to the successful management of colostrum.

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CHAPTER 2

LITERATURE REVIEW

2.1 COLOSTRUM

2.1.1. INTRODUCTION

Colostrum is a mixture of lacteal secretions and constituents of blood serum, such as immunoglobulins (Ig) that accumulate in the mammary gland during the pre-partum dry period and are collected via milking of the early-lactating cow. Colostrum and the subsequent milk provide a complete diet which is essential to the survival of the neonate while the calf is unable to collect, chew or digest solid food (Kehoe *et al.*, 2007; Piccione *et al.*, 2009).

In ruminants, colostrum is the sole source of initial acquired (passive) immunity as no *in-utero* exchange of immune factors occurs. The Ig in colostrum combined with the initial ability of the neonate gut to allow unrestricted passage thereof, act as passive immunization. However, both Ig type G (IgG) titre and gut permeability rapidly decrease within the initial 24 hours post-partum. Complete gut closure occurs approximately 24 hours post-partum (Larson *et al.*, 1980; Stanley and Bush, 1985; Arthington *et al.*, 2000; Weaver *et al.*, 2008). It is, therefore, essential to deliver an adequate supply of colostrum which is rich in IgG within this narrow window of opportunity (approximately 24 hours post-partum) to ensure best results. (Moore *et al.*, 2005). It is estimated that “50% of New Zealand calves have had inadequate colostrum” (Wesselink *et al.*, 1999).

The ingestion of optimal amounts of good quality colostrum is critical to the well-being and survival of the newborn calf. It supports the calf in adapting to its new environment whilst establishing passive immunity. Additionally, colostrum aids in the development and physiological functioning of the gastrointestinal tract (GIT) and influences the calf's metabolic systems and nutritional status (Lee *et al.*, 1995; Odle *et al.*, 1996; Guilloteau *et al.*, 1997; Hadorn *et al.*, 1997; Bühler *et al.*, 1998). Colostrum is rich in nutrients such as fats, proteins and peptides, fat-soluble vitamins, minerals and a variety of enzymes (Campana and Baumrucker, 1995). In addition to Ig, colostrum contains high levels of bioactive components such as growth factors, hormones, lactoferrin, lysozyme and

lactoperoxidase. With the exception of lactose these compounds are plentiful in the first colostrum but they decrease rapidly to the levels found in mature milk (at approximately day 8 post-partum) (Ronge and Blum, 1988; Piccione *et al.*, 2009).

Several contributing factors have been associated with the efficiency of passive immunity acquired by the newborn calf. These factors include, but are not limited to:

1. Age of calf at the initial feed (timing of the first colostrum feed) as the mechanism of pinocytosis (process during which Ig is absorbed by the GIT) diminishes gradually from 12-24hrs post-partum (Kruse, 1970 (a) & (b); Stott *et al.*, 1979; Bush and Stanley, 1980).
2. Mass of colostrum ingested during the first 24hrs of life. The smaller the mass the lower the colostral Ig levels (CIL) (Radostis *et al.*, 2000; Ghetie and Ward, 2000).
3. Concentration of IgG in the initial feed (colostrum quality). The lower the titre the poorer the colostral Ig transference (CIT) (Radostis *et al.*, 2000; Ghetie and Ward, 2000).
4. The degree of selectivity exerted by the intestinal epithelium (Weaver *et al.*, 2008).

Of these, Ig mass is by far the most important influencing factor. The feeding of quality colostrum to dairy calves is often insufficient (Roy, 1980; White and Andrews, 1986; NAHMS 1993; NAHMS 2002). Conversely the management and feeding of high quality colostrum might reduce calf mortality and morbidity, strengthen immunity and increase longevity of animals. (Donovan *et al.*, 1998; NAHMS 1993; NAHMS 2002)

2.1.2. COMPOSITION AND QUALITY OF COLOSTRUM

Good quality colostrum contains more than 50 mg Ig/ml. To achieve a stored supply of colostrum, only good quality colostrum from the first milking should be kept and may be frozen for up to 12 months without a significant loss in Ig content (Arthington, 2001). Only first milking colostrum should ever be used for the initial colostrum feed. The composition of colostrum is significantly different when compared to that of whole milk as can be seen in table 2.1.

Table 2.1: Approximate composition of colostrum and whole milk*

| <i>Item</i> | <i>1st milking (colostrum)</i> | <i>11th milking (whole milk)</i> |
|-------------------|---|---|
| Total solids (%) | 23.0 | 13.0 |
| Total protein (%) | 14.0 | 4.0 |
| Casein (%) | 4.8 | 2.5 |
| Ig (%) | 6.0 | 0.09 |
| Fat (%) | 6.7 | 4.0 |
| Lactose (%) | 2.7 | 4.9 |
| Minerals (%) | 1.0 | 0.74 |
| SG (approximate) | 1.056 | 1.032 |

* Adopted from Rice and Rogers, 1990

The Ig volume of the colostrum from third and older lactation, healthy cows are generally greater than those of younger cows. This occurs as older dams have been exposed to more diseases (field strains) and/or vaccines and they then have had the opportunity to develop Ig against such disease organisms. It is preferable to feed calves colostrum from such cows (Kruse, 1970(b); Devery-Pocus and Larson, 1980; Pritchett *et al.*, 1991; Morin *et al.*, 2001).

A calf should be fed at least 2 L – 4 L (approximately 5% - 10% of its body weight) of good quality colostrum as a first meal. Newborn calves should ideally be fed colostrum as soon as possible after birth, preferably within 30 minutes to 1 hour and then again 6-12 hrs (2L – 4L) later, totalling 4 L – 8 L within 24 hrs. This will improve the chance of ingesting the required minimum Ig concentration (200 g of Ig) (Kruse, 1970 (b); Arthington, 2001). Because dairy farmers feed fixed volumes of colostrum and whole milk it is critical to determine the Ig concentration content to assure adequate transfer of passive immunity.

2.1.3. ROLE OF COLOSTRUM FOR THE NEWBORN CALF

Calves are agammaglobulinemic at birth (Braun *et al.*, 1978; Halliday, 1978; Aldridge *et al.*, 1992; Weaver *et al.*, 2008). This means that calves are born without blood Ig. Maternal Ig are not transferred across the placenta during pregnancy and newborn calves are unable to produce their own Ig within the first weeks after birth. Calves therefore need to acquire Ig post-partum and depend on colostrum from the dam to acquire passive immunity (Quigley *et al.* 2002). The proportion of Ig that reach the blood post-absorption is however dependent on the quality and volume of colostrum (mass) fed to the neonate during the early hours of its life. The colostrum Ig consists mainly of type IgG1 as well as IgG2, IgM and IgA. Following absorption these IgA distribute through the animal's body. The

absorbed IgA protect the animal against systemic invasion of pathogens whilst unabsorbed antibodies play an important role in protecting against intestinal diseases. Calves will start to produce their own Ig approximately 10 days post-partum, reaching normal serum levels by 8 weeks of age and maturing at 5-6 months of age (Corbett, 1991; Hein 1994).

For maximum efficiency of passive transfer colostrum needs to be fed timeously in adequate quantities and must be of good quality. The Ig concentration of colostrum fed to the bovine neonate is a determining factor of post-colostral serum Ig concentration levels (Kruse. 1970 (a); Morin *et al.*, 1997; Morin *et al.*, 2001). Colostrum density is related to the protein content and the level of Ig therein i.e. the SG is indicative of colostrum quality (Morin *et al.* 2001).

2.1.4. IMMUNOGLOBULIN (Ig)

Ig are large proteins that transfer from the dam's blood to the colostrum in the udder during the dry period. The bovine mammary gland actively assists in regulating the Ig titre in colostrum. Mammary epithelium does not synthesize Ig, and Ig enters colostrum through a selective receptor-mediated intracellular route (Lacy-Hulbert *et al.*, 1999).

Bovine colostrum contains three types of Ig: IgG, IgM and IgA. These account for 75%-90%, up to 5% and up to 7%, respectively, of the total Ig in colostrum.

Immunoglobulin A (IgA) is an antibody that plays a critical role in mucosal immunity. It is produced by the resident intramammary plasma cells from where it is translocated, via the blood, across the mammary epithelial cells (MEC). This transport is regulated by changes in the endocrine system around parturition (Barrington *et al.*, 2001; Rincheval-Arnold *et al.*, 2002; Wilson and Butcher, 2004). The secretory form of IgA (sIgA) is the main Ig found in mucous secretions including tears, saliva, colostrum and secretions from the urinary tract, gastrointestinal and respiratory epithelium. It is also found in small amounts in the blood. The secretory component of sIgA protects the Ig from being degraded by proteolytic enzymes, thus sIgA can survive in the harsh environment of the gastrointestinal tract and provide protection against microbes that multiply in body secretions (Besser *et al.*, 1988a; Besser *et al.*, 1988b; Junqueira and Carneiro, 2003).

Immunoglobulin M (IgM) is the largest Ig in the circulatory system. It is the first Ig to appear in response to initial exposure to antigens. IgM do not pass across the placenta. These two biological properties of IgM make it useful in the diagnosis of infectious diseases. Demonstrating IgM in a patient's serum indicates recent infection or, in a neonate's serum, indicates intrauterine infection (Houghton Mifflin Company, 2004).

Immunoglobulin G (IgG) is the most abundant Ig and is almost equally distributed between blood and tissue fluids, constituting 75% of serum-Ig. IgG molecules are synthesised and secreted by plasma B-cells. IgG antibodies are predominantly involved in the secondary immune response (IgM is the main Ig involved in primary response). The presence of specific IgG generally corresponds to maturation of the Ig response. This is the only isotype, because of its size, that can pass through the placenta in small amounts, providing protection to the foetus *in-utero*. Along with IgA secreted in the colostrum, residual IgG absorbed through the placenta provides the neonate with humoral immunity before its own immune system develops. Colostrum contains a high percentage of IgG, particularly bovine colostrum (Butler, 1994; Korhonen *et al.*, 1995; Meulenbroek, 1996).

There are 2 isotypes of IgG: IgG₁ and IgG₂ (Larson *et al.* 1980; Williams *et al.*, 1990). IgG₁ accounts for 80% of IgG and is predominantly absorbed from the calf's intestine. The two types of IgG combined ensure passive immunity in the neonate. Milk from the second milking post-partum contains only on average 55% of the IgG levels found in milk from the first milking. It is thus stated that when referring to the capacity to build passive immunity in the new born calf, only milk from the very first milking can be referred to as true colostrum. All milk from subsequent milkings should be referred to as transitional milk (Butler, 1983; Radostis *et al.*, 2000; McGuirk and Collins, 2004).

A negative correlation exists between the weight of colostrum in the first colostrum milking and the IgG₁ content thereof (Pritchett *et al.*, 1991; Maunsell *et al.*, 1999). Pritchett *et al.* (1991) suggest that the decrease in colostral IgG₁ titre in large volumes of colostrum might be due to a dilution effect of the IgG₁ in such large volume of colostrum i.e. the more colostrum a cow produces during her first milking, the less likely are the chances that it will contain a sufficient concentration of IgG₁.

2.1.4.1. Ig - TRANSPORTATION IN THE CIRCULATORY SYSTEM

Ig is the central immunological link that transpires when passive immunity is transferred from the cow to her calf. There is a variety of identified transport mechanisms which varies between species of mammals.

Ig is in fact an accurate representation of a cow's history with regards to her exposure to environmental antigens and her immune response thereto. Ig can either be from systemic or local origin and gets transported into the cow udder through the epithelial cells via a complex receptor-mediated mechanism (Lacy-Hulbert *et al.*, 1999). Ig binds to receptors, which is specific for the Fc portion of an Ig molecule, at the basolateral surface of the mammary epithelial cells (Butler and Kehrli, 2005). The receptor responsible for transcytosis of IgG is known as the FcRn receptor. The binding is highly dependent on pH, with the quality of the binding increasing in an acidic pH environment. The receptor bound Ig is now transported to the apical end of the cell and released into the alveolar lumen. From the udder, colostrum is harvested by the calf through the suckling process. Once in the calf the macromolecules (colostrum) enters the gastro-intestinal tract (GIT) which normally has a digestive function, however, Ig has the ability to remain stable to provide its protective benefits to the calf. The absorbed Ig is released into the lamina propria, a thin layer of loose connective tissue which lies beneath the epithelium and together with the epithelium constitutes the mucosa. From here it is either taken up into the vascular system for circulation or it can also provide local immunological functions within the GIT. The transfer of passive immunity between mother and offspring of the same species is known as homologous transfer of passive immunity. This is opposed to heterologous transfer of passive immunity, when Ig is obtained from one species to benefit the passive immunity of another species (Walter and Theil, 2011).

IgG is the most abundant Ig and is mainly derived from serum, and the serum half-life for IgG is typically longer, 1-3 weeks, when compared to IgA and IgM which is 1-2 days. IgG₁ has a slightly shorter serum half-life than IgG₂. The concentration of IgG₁ and IgG₂ in serum is approximately equal; however, in bovine colostrum the IgG₁ concentration is many fold greater (Cervenak and Kacskovics, 2009). It may be that most of the IgG₂ that is taken up by the mammary epithelial cells during the colostrum formation process is actually recycled to extracellular fluids rather than being passed into the alveolar lumen (Junghans and Anderson, 1996).

One must remember that a cow is in an immunosuppressed state during the peri-partum period due to the transfer of Ig to colostrum (Mallard *et al.*, 1997).

2.1.4.2. Ig - MODES OF ACTION

Bovine colostrum is made up of many complex factors such as cytokines, lymphokines, proline-rich polypeptides, leukocytes, lactoferrin (antimicrobial), lysozymes (antibacterial) and all of the Ig (IgG, IgA, IgM, IgD, IgE). These factors interact and work together to initiate and regulate the intensity and duration of the immune response hence there are no easy-to-describe mode of action (Walter and Theil, 2011).

One mode of action, attributed to IgG and IgM, is to increase the level of phagocytosis at the site of infection by increasing the levels of the appropriate Ig. IgG binds to many kinds of pathogens i.e. viruses, bacteria and fungi. It defends the body by immobilizing pathogens, phagocytosis of pathogens or neutralizing their toxins. IgA primarily defends seromucous tissues by blocking adherence of micro-organisms and their toxins at epithelial cell level (Leitner *et al.*, 2000). In addition, IgA has a major role in suppressing the proinflammatory response to oral antigens. After gut closure, any IgG that might still be localized in the lamina propria will contribute to the proinflammatory response in the intestines (Walter and Theil, 2011).

2.1.5. FACTORS INFLUENCING THE QUALITY OF COLOSTRUM

The quantity of transferred Ig is dependent on factors such as breed, cow health, nutrition, parity and calving season. The period from birth to first colostrum meal (timing) and the mass of colostral Ig (a function of the amount of colostrum ingested and the Ig concentration thereof) are the two most important factors that influence transfer of passive immunity (McGuire *et al.* 1976; Pritchett *et al.*, 1991). Whilst the timing is important to maximize Ig absorption before the onset of gut closure at 24 hrs post-partum the neonate also needs to ingest a large volume (4L-8L) of colostrum with a large concentration of Ig (>200g Ig) to allow for sufficient passive transfer of immunity.

a. Breed

In 1981 Muller and Ellinger reported that colostrum from various breeds have various Ig contents. Among the common dairy breeds, Holsteins tended to have the

lowest and Jerseys the highest levels of Ig. In this study colostrum of Jersey cows contained 9.0% Ig, Ayrshire cows 8.1% Ig, Brown Swiss cows 6.6% Ig, Guernsey cows 6.3% Ig and Holsteins cows 5.6% Ig (Guy *et al.*, 1994). Dairy breeds produce lower titres of Ig in their colostrum than beef breeds. Breed differences could be attributed to genetic differences and/or, dilution effects associated with the various volumes and quality of milk each breed produce (Shearer *et al.*, 1992).

b. *Cow health*

The colostrum quality that a cow produces is directly correlated to her health status. Cows with low trace minerals such as calcium, magnesium and iron will also suffer from reduced immunity, decreased disease resistance, slower recovery and more relapses of sickness with a poorer response to vaccination. These factors all impact negatively on colostrum quality. Good-quality colostrum is thick and creamy in appearance. Healthy cows in good condition that have been vaccinated are more likely to produce good quality colostrum. Inferior colostrum can occur when cows are dry less than four weeks, when animals are milked before calving, and when animals are first-calf heifers. Thin or watery colostrum should not be fed if there is a source of good quality colostrum available, either frozen or fresh (Pritchett *et al.*, 1991; McGuirk and Collins, 2004).

c. *Parity*

Cows from latter parities will produce superior quality colostrum compared to cows from earlier parities. Across dairy breeds the total colostral Ig titre for first lactations increases from 5.91% Ig, to second at 6.26%, third at 8.15% and fourth and higher lactations at 7.49% Ig (Muller and Ellinger, 1981; Hunt, 1990; Corbett, 1991, Piccione *et al.*, 2009). Corbett found in 1991 that the Ig titre of first calf heifers were 28 mg/ml, second calvers 59 ml/mg, third calvers 82 mg/ml and forth and subsequent calvers 73 mg/ml. As the majority of dairy herds contain 25%-30% first calving heifers a large proportion of calves that are fed colostrum from their dams may not be well protected from disease (Hunt, 1990; Corbett, 1991).

d. *Season of calving*

The Ig content of colostrum is generally lower in the hotter months (summer and spring) compared to those from the cooler months (autumn and winter) and is

attributed to cow discomfort due to elevated temperatures or “heat stress” (Shearer *et al.*, 1992; Morin *et al.*, 1997). The severity of environmental conditions during the season of calving further affects factors such as body condition score (BCS) from dry-off to calving and the general health status of the cow. These factors have been found to influence colostrum quality, as an increase in BCS will increase Ig concentrations and *vice versa* (Shearer *et al.*, 1992).

2.1.6 EVALUATION OF COLOSTRUM QUALITY

A colostrometer is a calibrated device, or hydrometer, used for a quick, easy and economical on-farm estimation of colostrum quality (Ig in mg/ml) and is based on colostral specific gravity (SG) (Fleenor and Stott, 1980). Other Ig titre determination tests determine Ig values in plasma serum. The most effective and popular Ig determination procedures include Radial Immunodiffusion Assay (RIA) and Enzyme-linked immunosorbent assay (ELISA). The ELISA is a serological technique to detect the presence of an antibody or an antigen in a sample. Colostral Ig should preferably be greater than 50 mg/ml. A linear relationship exists between colostral SG and Ig titre. This relationship provides an equation, when calculated by regression model, to estimate the Ig concentration from the SG of whole fresh colostrum (Fleenor and Stott, 1980; Quigley *et al.*, 1994). The hydrometer is calibrated for Ig titres at 5 mg/ml intervals for the range 0-180 mg/ml. Three color-coded quality regions are displayed: poor (red) for less than 22 mg/ml, moderate (yellow) for 22-50 mg/ml and excellent (green) for values above 50 mg/ml (Table 2.2). Table 2.2 additionally demonstrates the correlated values between colostral SG and Ig titre (Fleenor and Stott, 1980; Quigley *et al.*, 1994). The manufacturer’s directions require measurements to be made at room temperature (20°C) as Ig titre varies with colostral temperature (Fleenor and Stott, 1980). When colostrometer measurements for the same sample are taken at various temperatures the measurement at the higher temperatures (above 20°C) will reveal lower colostral SG values than those taken at 20°C. However, from a practical point of view this is not a problem as it will preclude the storing of inferior colostrum. The reason for this is that the measurement above room temperature will underestimate Ig content rather than over-estimate its Ig content (Mechor *et al.*, 1992).

Figure 2.1 illustrates the 2 components of the colostrometer. It consists of a measuring cylinder (Fig 2.1 – right) which holds 200ml-250ml of freshly harvested colostrum ready for measurement. The colostrometer (Fig 2.1 – left) is floated in the measuring cylinder

without touching the sides. A reading is then taken from the calibrated scale on the shaft of the colostrometer.

Figure 2.2 illustrates the process of flotation of the colostrometer in the measuring cylinder. As the measurement is based on density, the deeper the colostrometer sinks the less dense is the colostrum and the poorer is the quality of the sample in terms of Ig titre.

Figure 2.1



Figure 2.1: Components of the colostrum

densimeter.

Ref

#1:

http://budaxperah.files.wordpress.com/2009/04/17494_a.jpg. Accessed 08/07/10 at 15h00.



Figure 2.2(a)

Figure 2.2(b)

Figure 2.2: Illustration of the measurement of a good (Fig. 2.2a) and a poor (Fig. 2.2b) colostrum sample. *Ref #2:* <http://www.colostrometer.com/support.asp?ID=2>. Accessed 08/07/2010 at 15h05.

Table 2.2 illustrates reference colostrometer readings: column 1 SG, the quality of the colostrum sample in column 2 and column 3 the estimated Ig value for the sample i.e. a sample with an SG of 1.027 is of poor quality and is estimated to have a Ig value of 1.42.

Table 2.2: Colostral globulin concentration and quality, based on colostral specific gravity*
^amg/ml and ^baverage whole milk specific gravity measured at room temperature 20°C.

| Specific Gravity | Quality | Globulin ^a |
|--------------------------|-----------|-----------------------|
| 1.027 | Poor | 1.42 |
| 1.028 | Poor | 3.97 |
| 1.029 | Poor | 6.52 |
| 1.030 | Poor | 9.06 |
| 1.031 | Poor | 11.61 |
| 1.032^b | Poor | 14.16 |
| 1.033 | Poor | 16.70 |
| 1.034 | Poor | 19.25 |
| 1.035 | Poor | 21.80 |
| 1.036 | Moderate | 24.35 |
| 1.037 | Moderate | 26.89 |
| 1.038 | Moderate | 29.44 |
| 1.039 | Moderate | 31.99 |
| 1.040 | Moderate | 34.53 |
| 1.041 | Moderate | 37.08 |
| 1.042 | Moderate | 39.63 |
| 1.043 | Moderate | 42.18 |
| 1.044 | Moderate | 44.72 |
| 1.045 | Moderate | 47.27 |
| 1.046 | Moderate | 49.82 |
| 1.047 | Excellent | 52.36 |
| 1.048 | Excellent | 54.91 |
| 1.049 | Excellent | 57.46 |
| 1.050 | Excellent | 60.01 |
| 1.051 | Excellent | 62.55 |
| 1.052 | Excellent | 65.10 |
| 1.053 | Excellent | 67.65 |
| 1.054 | Excellent | 70.19 |
| 1.055 | Excellent | 72.74 |
| 1.056 | Excellent | 75.29 |
| 1.057 | Excellent | 77.84 |
| 1.058 | Excellent | 80.38 |
| 1.059 | Excellent | 82.93 |
| 1.060 | Excellent | 85.48 |
| 1.061 | Excellent | 88.02 |
| 1.062 | Excellent | 90.57 |
| 1.063 | Excellent | 93.12 |
| 1.064 | Excellent | 95.67 |
| 1.065 | Excellent | 98.21 |
| 1.066 | Excellent | 100.76 |
| 1.067 | Excellent | 103.31 |
| 1.068 | Excellent | 105.85 |
| 1.069 | Excellent | 108.40 |
| 1.070 | Excellent | 110.95 |
| 1.071 | Excellent | 113.50 |
| 1.072 | Excellent | 116.04 |
| 1.073 | Excellent | 118.59 |
| 1.074 | Excellent | 121.14 |
| 1.075 | Excellent | 123.68 |
| 1.076 | Excellent | 126.62 |

*Adopted from Fleenor and Stott.

**All readings taken at room temperature (20°C).

2.1.7 CORRELATION BETWEEN FEEDING TIME AND Ig ABSORPTION

One-third of the gut's absorptive ability is lost within 6 hours post-partum and this loss in absorption increases to nearly 90% by 24 hrs post-partum (Matte *et al.*, 1982; Barrington *et al.*, 2001). The Apparent Efficiency of Absorption (AEA) of Ig by calves can be measured on-farm; this is done to determine whether or not the different factors involved in colostrum management are effective i.e. whether passive transfer of Ig was successful. The AEA is a method of balancing the variability in actual blood Ig concentrations by accounting for differences in plasma volume as related to body weight (BW). By knowing the mass of Ig ingested i.e. quantity and quality colostrum, the plasma Ig concentration following Ig absorption and the plasma volume, one can calculate the efficiency of IgG absorption (AEA)*. This value indicates how much of the IgG fed to a neonate actually enters the calf's bloodstream. This value rarely exceeds 35% (Arthington *et al.*, 2000).

*AEA % can be calculated by using the following formula:

$$[(\text{IgG} \times \text{PV}) / 100 \text{ g IgG}] \times 100 = \% \text{ AEA}$$

Where,

- IgG (Plasma IgG in g/L or mg/ml is measured by blood sample from the calf), this value is a measure of the degree of passive immunity; it however does not indicate efficiency of the IgG absorbed prior to gut closure.
- PV (plasma volume in g/L or mg/ml is estimated from Table 2.3)

Table 2.3, as compiled by Quigley and co-workers (1997), illustrates estimates of the PV values for Holstein and Jersey calves at various body weights, and ages (hours) post-colostrum feed. This is a standard reference table (Quigley *et al.*, 1997) for AEA% calculation.

Table 2.3: Estimated plasma volume (PV) values of calves at various body weights and ages post colostrum feed.

| PLASMA VOLUME IN CALVES | | | | | | | | | | | |
|--|---------------------------|------|-------|-------|-------|------|-------------------------|------|------|-------|-------|
| Estimates of plasma volume (PV) in Holstein and Jersey calves ¹ | | | | | | | | | | | |
| BW (Kg) | Age of Holsteins in hours | | | | | | Age of Jerseys in hours | | | | |
| | 22h | 23h | 24h | 25h | 26h | | 22h | 23h | 24h | 25h | 26h |
| | | | | | | ml | | | | | |
| 20 | ... | ... | ... | ... | ... | | 1604 | 1719 | 1835 | 1950 | 2065 |
| 25 | 2279 | 2394 | 2509 | 2625 | 2740 | | 1912 | 2028 | 2143 | 2258 | 2374 |
| 30 | 2587 | 2702 | 1818 | 2933 | 3048 | | 2221 | 2338 | 2452 | 2567 | 2682 |
| 35 | 2895 | 3011 | 3126 | 3242 | 3357 | | 2529 | 2645 | 2780 | 2875 | 2991 |
| 40 | 3204 | 3319 | 3435 | 3550 | 3665 | | ... | ... | ... | ... | ... |
| 45 | 3512 | 3628 | 3743 | 3859 | 3974 | | ... | ... | ... | ... | ... |
| | | | | | | % BW | | | | | |
| 20 | ... | ... | ... | ... | ... | | 8.03 | 8.94 | 9.84 | 10.75 | 11.65 |
| 25 | 9.11 | 9.58 | 10.04 | 10.50 | 10.98 | | 7.58 | 8.31 | 9.03 | 9.75 | 10.48 |
| 30 | 8.62 | 9.01 | 9.39 | 9.78 | 10.16 | | 7.28 | 7.88 | 8.49 | 9.09 | 9.69 |
| 35 | 8.27 | 8.60 | 8.93 | 9.26 | 9.59 | | 7.07 | 7.58 | 8.1 | 8.62 | 9.13 |
| 40 | 8.01 | 8.30 | 8.59 | 8.88 | 9.16 | | ... | ... | ... | ... | ... |
| 45 | 7.81 | 8.06 | 8.32 | 8.57 | 8.83 | | ... | ... | ... | ... | ... |

The following formula is used to calculate the plasma Ig concentration of the neonate:

$$\text{Plasma IgG (g/L)} = \frac{\text{colostrum quality (g/L)} \times \text{colostrum intake (L)} \times (\text{AEA})}{\text{plasma volume (PV)}}$$

(Kehoe *et al.*, 2007)

2.2. CALF DISEASES

2.2.1. COMMON SYMPTOMS SEEN IN CALVES

Calves are generally susceptible to infection and/or invasions from pathogens present in the calving area prior to and during birth. The small intestine absorbs the large IgG molecules from colostrum within the first 24hrs post-partum to ensure passive immunity. This absorption may also include bacteria which might be present at the time of absorption i.e. researchers found that calves that do not readily absorb colostrum are more likely to absorb pathogens like *E. coli*. The 3 most important syndromes that are associated with calves, worldwide, and that will be reported on in this study are septicaemia, calf diarrhoea or scours and pneumonia (McGuirk and Ruegg, 2011).

a. *Septicemia*

Calves may contract septicaemia *in-utero*, during or immediately after birth. It is associated with disease-producing organisms or their toxins in the blood of the calf and is the result of a gram negative bacterial infection, mostly by *E. coli* and *Salmonella* spp. The route of infection can be via a variety of sources i.e. blood or placenta from an infected dam, the calf's umbilical stump, mouth, inhalation or open wounds. Septicaemia is the most serious condition a newborn calf may develop because many of the organs are damaged by the circulating blood-borne disease. This makes septicaemia difficult to treat and survival rates are low as a result. Early clinical signs of septicaemia, within 5 days post-partum, may include poor suckling, weakness, reluctance to stand and depression. Swollen joints, diarrhoea, pneumonia, navel ill and/or meningitis may develop at a later stage. It is important to note that fever is not consistent with septicemic calves. Most

septicemic calves do, however, have a history of inadequate colostrum intake (Roy *et al.*, 1990; Radostis *et al.*, 1999; McGuirk and Ruegg, 2011).

b. *Calf diarrhoea*

Calves are mostly infected from the environment within 1-3 days of life. Many serotypes of *E.coli* are found but the most common cause of calf diarrhoea is from enterotoxigenic *E. coli*. Dehydration caused by this pathogen is normally severe and if neglected or left untreated may cause death even before the onset of diarrhoea. As the course of the disease is so rapid, weakness to death may occur within 24 hours. Fluids are critical to survival as antibiotics seldom have an effect on the outcome of the disease. Vaccination of the dry cow, adequate bio-security and a sufficient intake of quality colostrum can eliminate or prevent this disease (Hunt, 1985; Karmali, 1989; Roy *et al.*, 1990; Radostis *et al.*, 1999).

c. *Pneumonia*

Pneumonia is an inflammatory condition of the lungs. The occurrence of a pneumonia outbreak in calves is frequently marked by the isolation of more than one pathogen. Risk factors associated with pneumonia include FPT, prolonged exposure to adult cattle and inadequate ventilation of warm housing. Pneumonia has a significant impact on future growth and productivity of the calf. Pathogens responsible for pneumonia in calves are, and might be a combination of, *Pasteurella haemolytica*, *Pasteurella multocida*, *Mycoplasma dispar*, *Mycoplasma bovis*, *Hemophilus* spp, *Actinomyces* spp and *Salmonella dublin*. Pneumonia is typically first recognized after weaning when calves are grouped together for the first time. However, in many herds the first episode can occur as early as 2 weeks after birth and is not detected. Typical clinical signs of pneumonia include loss of appetite, respiratory distress, dry cough, nasal discharge and body temperatures above 41°C. Ear infections, which are caused by the same pathogens, can result from respiratory disease and indicate of pneumonia (Roy *et al.*, 1990; Radostis *et al.*, 1999; Potter, 2007; McGuirk and Ruegg, 2011).

2.2.2. PATHOGENS CAUSING THE 3 MOST COMMON CALF SYNDROMES

The main pathogens that calves encounter are typically *E. coli*, *Salmonella* spp, *Pasteurella* spp. and *Eimeria* spp. (Roy, 1990; House *et al.*, 2004; Maddox-Hyttel and Vestergaard, 2003).

1) *Escherichia coli* spp. (*E.coli*)

E. coli are gram negative, environmental coliforms carried by ruminants. Most *E. coli* are harmless, however, a small proportion are an important cause of disease worldwide. Pathogenic *E. coli* is an uncommon but serious cause of gastroenteritis. Certain *E. coli* strains produced a toxin, which was initially called verotoxin because of its distinct effect on Vero cells. The strain most commonly isolated in calves is K99. *E. coli* is also part of the normal gut flora and gets excreted in the faeces. *E. coli* may persist for more than two years in the environment. It is the most common cause of calf diarrhoea and occurs when the newborn calf ingests it from contaminated manure, mud or other material before or along with colostrum ingestion. It can manifest as early as 3 days post-partum. *E. coli* is seldom treated successfully. Stress is a predisposing risk factor and it was found that shedding at weaning is far more than that pre-weaning (Garber *et al.*, 1995). The most common symptoms are dehydration, acute watery diarrhoea and fever. *E.coli* can be prevented by calving in clean, dry areas and keeping colostrum clean and refrigerated or frozen. (Karmali, 1989; Roy, 1990; Garber *et al.*, 1995; Pennington, 2010; McGuirk and Ruegg, 2011).

2) *Salmonella* spp.

Infections with *Salmonella* are endemic to many intensive dairy farms where colostrum and un-pasteurized milk are common sources of infection. *Salmonella* spp is a very important cause of diarrhoea and the infected calf may in addition develop septicaemia (House *et al.* 2004). Outbreaks of this disease typically reflect a combination of environmental conditions and management practices culminating in impaired host immunity and calves exposed to high challenges of *Salmonella* spp. These bacteria are also the cause of pneumonia. Infections typically occur at 5-14 days of age. Blood and intestinal casts may be observed in the feces. During clinical illness, *Salmonella* spp infects the salivary glands and is shed in both saliva and nasal discharges. The duration of the disease may be up to 2

weeks as calves respond slowly to treatment. *Salmonella dublin* can cause a calf to be a carrier or source of infection for life. People handling calves that shed *Salmonella* spp may also contract Salmonellosis and become ill. The most effective way to prevent the disease is by the implementation of good sanitary practices. *Salmonella* spp is sensitive to most disinfectants, however, organic material reduces the effectivity of disinfectants, and therefore all contaminating organic debris should be removed. Feeding utensils and personnel may contribute significantly to the spread of *Salmonella* spp between calves, therefore, regular disinfection and sanitary practices are critical. A feature of intensive dairy farms is large volumes of manure, which may become a dynamic reservoir. The combination of warmth and moisture may lead to the presence of 10 *Salmonella*/gram multiplying to 10⁷ *Salmonella*/gram within 24 hours (Roy *et al.*, 1990; House *et al.* 2004). Practices minimizing water or moisture retention will mitigate the environmental multiplication of *Salmonella* spp. When considering the high risk of disease during the transitional period, from close up to fresh cows, priority should be given to management practices of enclosed areas (e.g. calving pens/camps). Cows lying in *Salmonella* spp-contaminated areas may become covered in *Salmonella* spp bacteria, and as many as 50% of calves may shed *Salmonella* spp in their feces within 24 hours post-partum if they were exposed to a *Salmonella* spp-contaminated area within the first 6 hours of life. Dairy lagoons or slurry tanks function under anaerobic conditions, therefore pathogen reduction may take months. A number of studies have investigated the survival rate of *Salmonella* spp in liquid cattle waste maintained under anaerobic conditions. It was found that the bacteria may survive for up to 286 days in such conditions (Findly, 1972). The survival of *Salmonella* in slurry is further enhanced by a reduction in temperature and an increase in solid contents (Jones, 1992). Temperatures below 10°C and slurry solid contents of greater than 15% are found to give the best rates of survival. The survival of *Salmonella* spp is also greater in aerated environments than in anaerobic conditions (Munch *et al.* 1987). During outbreaks, diarrhoeic animals may shed up to 10⁸ *Salmonella* spp/gram feces. The number of *Salmonella* spp required to produce clinical disease is dependant on the virulence of the serotype and the immunity of the host. FPT, feeding of contaminated colostrum and poor nutrition are contributing factors to Salmonellosis. Studies show that cows vaccinated twice with killed bacterins, prior to calving, passed on IgG to their calves through colostrum, and this protection appears to be partial until the calf reached 3 weeks of age (Roy *et al.*, 1990; House *et al.*, 2004; McGuirk and Ruegg, 2011).

3) *Pasteurella* spp.

These include *Pasteurella haemolytica*, *Pasteurella multocida*, *Pasteurella haemolytica* and *Pasteurella multocida* and are common organisms of the nasopharynx of healthy bovines (Frank, 1989). They become problematic once certain tissues are damaged or stressed. These bacteria compound respiratory diseases primarily caused by other bacteria or viruses. A study has shown that *Pasteurella haemolytica* was isolated from the lungs of less than 40% of calves dying from pneumonia (Franken *et al*, 1988; Roy *et al.*, 1990). *Pasteurella* infections are spread by inhalation, direct contact and ingestion of contaminated feed or water and by oral discharge from infected individuals. The animal's innate resistance is generally able to control *Pasteurella*. The bacteria, reproducing at a slow rate, float in the mucus of the nose and throat and are destroyed by locally produced antibodies. These are easily removed by the normal clearing mechanisms found in healthy animals. *Pasteurella* spp manifest when the normal defenses of the animal are compromised following infections with other bacteria and or viruses common to cattle such as Infectious Bovine Rhinotracheitis (IBR), Bovine Respiratory Syncytial Virus (BRSV), Bovine Viral Diarrhoea Virus type I and II (BVDV I and II) and Parainfluenza virus type 3 (PI₃). The bacteria attach to the lining of the respiratory tract from where they spread throughout the lungs. The severity of the disease is dependant on the species of responsible organism involved. *Pasteurella haemolytica* tends to be more pathogenic than *Pasteurella multocida*. Both however can result in animal death. Indirect evidence exists that Ig to respiratory pathogens mediate resistance to pneumonia in neonates and that low serum Ig is associated with increased incidence of pneumonia in dairy calves (Corbeil *et al*, 1984; Hodgins and Shewen, 1994).

4) *Eimeria* spp.

Eimeria spp is a protozoal organism that is ingested from the environment by young animals and is responsible for coccidiosis. The species most commonly pathogenic in calves are *Eimeria zuernii* and *Eimeria bovis*. Coccidiosis is a condition associated with damage the gut wall. This has a negative effect on the future growth rate of infected calves. The major predisposing factors of coccidiosis are stress manifestation and age. The condition is associated with acute diarrhoea, dehydration and subsequent weight loss. Coccidia may cause secondary infections leading to early mortality. Sub-clinical infections impair resistance to other secondary infections (Roy *et al.*, 1990; Maddox-Hyttel *et al.*, 2003,).

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CHAPTER 3

MATERIALS AND METHODS

3.1 INTRODUCTION

A research proposal and an application for ethics scrutiny was submitted to, and approved by, the UNISA Ethics Committee (CAES) on 02 February 2010. For the purpose of the research the following data were collected during the period 1 May 2010 to 31 October 2010.

1. Colostrum samples were collected for field evaluation of colostral SG and,
2. A questionnaire was developed and a survey was conducted amongst commercial dairy farmers of the Eastern Cape coastal region.

The Eastern Cape area constitutes 21.8% of the total milk production of South Africa (MPO – Lacto data, 2010). The Eastern Cape has a total of 387 registered milk producers. Nationally 7% of milk producers have 200-300 cows and 10% have more than 300 cows. (MPO –Lacto data, 2010).

3.2. STUDY AREA

The Eastern Cape is one of nine provinces in South Africa. The climate of the coastal region of the Eastern Cape is ideal for dairy operations and contributes significantly to the agriculture revenue of this province. This region enjoys mild to Mediterranean summers and moderate winters. Annually more sunshine days than any other province of South Africa is experienced in this area – more than 300 out of 365 days are sunny (MPO -Lacto data, 2009). This region is well watered with the lowland coastal belt, extending 60 km inland, having rain all year round. In Autumn/Winter (April to August) temperatures range from 7°C - 20°C and in Summer range from 16°C - 26°C with high humidity. Such climatic conditions favor the thermo neutral conditions required for dairy farming (MPO - Lacto data, 2009).



Figure 3.1 (a):
Outline map of
the Eastern
Cape Province



Figure 3.1 (b):
Map of the
Eastern Cape
coastal region.

Trial site.

3.2.1. TRIAL SITE SELECTION

The study was conducted on a single randomly selected leading commercial dairy farm in the Alexandria district of the Eastern Cape Province of South Africa. The chosen farm is one of six large dairy farms in the area but was chosen because it runs a Holstein Friesland herd. The other farms run Jersey and/or crossbred herds. The commercial colostrometer calibration is best suited to Holstein colostrum (Fleenor and Stott, 1980). This farm's infrastructure, quality of farm management and ability to perform extra ordinary recordkeeping supported its choice as the trial site.

The herd of the selected farm consists of more than 500 head of lactating Holstein cows. This farm practices a year round calving season with peaks occurring in May/June and July/August of each year.

This farm rears more than 300 heifer calves per annum. Calf diseases, confirmed by veterinary diagnosis, common to this area and specifically to this farm involve pathogens such as *Salmonella* spp, *E.coli*, *Eimeria* spp and *Pasteurella* spp. The annual calf mortality rate on this farm is above 7.5%.

Calves are separated from their dams 3-5 days post-calving. Neonates are fed 2 liters of colostrum less than 6 hrs post-partum with no follow-up feeding. Colostrum quality is measured by commercial colostrometer on this farm.

3.3. COLOSTRUM SAMPLES

3.3.1. STUDY DESIGN

A Complete Randomized Design (CRD) was used. Season was the treatment factor. The method of measurement constituted treatment with season.

3.3.2. COLOSTRUM SAMPLE SELECTION

The objective of this study was to assess the factors that influence colostral SG in dairy cows. Colostral SG was measured using a standard, calibrated commercial colostrometer as described (Morin *et al.*, 2001).

Colostrum samples (n=90) were collected from 90 randomly selected cows and allocated in accordance with the season of calving (autumn n=18, winter n=42, spring n=30).

3.3.3. COLOSTRUM SAMPLING PROCESS

Harvesting of the colostrum samples were done during the period from 01 May 2010 to 31 October 2010.

Unnursed cows were presented for hand-milking (harvesting) within 6 hours post-calving. The cows were identified by recording the number of their permanent ear tag on the data collection sheet. In the unlikely event of a cow not having a permanent ear tag (due to loss or otherwise), that cow was then excluded from the study and replaced by the next cow that calved. Cows without ear tags were excluded from the study on the basis of the individual cow record being inadequately traceable.

Fresh colostrum samples were collected from each individual cow. Pooled samples representing colostrum from each of the four quarters were presented for evaluation. The SG of each of the colostrum samples was measured using a colostrometer. Hands were washed before and after collection in a F10 disinfectant solution and, dried using disposable paper hand towels. The colostrometer and colostrometer cylinder was washed in F10 disinfectant between the evaluation of different samples and then dried with disposable paper towels. The samples were stored in a cooler box on ice immediately after the initial SG measurement. The samples were then transported to Alexandria, on the day of collection, where they were frozen for 20 days at a temperature of -18°C. No training was required to fill and freeze the 250 ml sample bottles of colostrum.

Colostrum samples from 19 first lactation cows were included in this study. The animals were healthy, as determined by visual examination, on the day of enrolment. Obvious outliers in terms of age and body condition score (BCS) were excluded from the study.

3.3.4. COLOSTRUM SG EVALUATION PROCESS

A volume of 250 ml fresh colostrum was poured into a KRUUSE measuring cylinder for testing (Fleenor and Stott, 1980). This was used to avoid surface tension error (Inner diameter ≤ 4.5 cm). A commercially available KRUUSE colostrum densimeter was used to evaluate the SG of each sample (Reading 1). SG was measured and recorded immediately

after collection of the sample by floating the colostrum densimeter in the colostrum without touching the sides of the measuring cylinder. The colostrometer is both calibrated and colour-coded by the reference manufacturer. The SG was measured by reading the scale from the colostrometer at the surface of the colostrum.

The colostrum temperature was measured manually by inserting a mercury thermometer into the colostrum in the measuring cylinder. The temperature was then recorded in °C. The measure of colostrum in the measuring cylinder was allowed to cool down to room temperature (approximately 20°C). As soon as it reached 20°C SG was measured and recorded again for reading 2 (Fleenor and Stott, 1980). The second reading was indicative of the effect of colostrum temperature on SG.

Immediately after the second measurements were recorded the colostrum samples were placed on ice and subsequently frozen in a domestic box deep freeze as described in section 3.3.2. This was done to simulate the process to minimize bacterial growth as would be done in practice when storing good quality colostrum for later use. No bacteriological quality assessment was done as it would not have been relevant to this study. The samples were also frozen to evaluate the possible loss of Ig in the sample after frozen storage over a period of time, as would be done in practice. After 21 days it was naturally thawed to room temperature and measured again (reading 3) for evaluation of Ig.

Colostrometer values were determined for each sample and SG calculated by using the equation:

$$SG = [(Colostrometer\ value + 2614)/2547] \text{ (Fleenor and Stott, 1980).}$$

Additional data recorded for further analysis and comparison included the calving season (time/month of year), age of the evaluated cows, number of calvings/lactations, health and vaccination records (Morin *et al.*, 2001).

3.3.5. DATA ANALYSIS (COLOSTRUM)

The SG measurement is a reasonable predictor of IgG content. However, the colostrometer is normally utilized under a variety of environmental conditions and various temperatures in the field, hence accuracy increases when IgG content is calculated using a regression

model. A regression model allows for comparison of colostrum samples whilst taking into consideration possible varying temperatures (Mechor *et al.*, 1992).

$$\text{IgG (mg/ml)} = 853 \times (\text{SG}) + 0.4(^{\circ}\text{C}) - 866$$

When colostrum SG is measured at 20°C as recommended, IgG values should be calculated using the following equation:

$$\text{IgG (mg/ml)} = 958 \times (\text{SG}) - 969$$

The regression model includes total protein, fat and milk solids (Mechor *et al.*, 1992).

The colostrum sample data obtained during this study was interpreted, analysed, summarised and presented in the form of charts, tables, percentages and averages.

3.3.6. DATA INTEGRITY AND ANALYSIS OF THE COLOSTRUM SAMPLES

Data were recorded on a data recording form in black ink. Each data sheet was identified by the farm name (trial site), the date of the recording and a heading describing the type of data. If a sheet was used to record data on more than one day, each day's data entry was initialled by the recorder. If a single sheet was used for a particular day, that sheet was signed by the recorder. Study data were kept under lock and key when not in use and access to the data was strictly controlled by the investigator.

3.3.7. STATISTICAL ANALYSIS

Experiment 1 (COLOSTRUM SAMPLING): All data, measured colostrometer readings and regression estimates on colostrum quality, were analysed using basic descriptive statistics and analysis of variance (ANOVA) procedures using the One-Way test in Minitab V15 (Minitab® 15. 1. 30. 0, ©2007 Minitab Inc.). LS mean differences were tested using Fischer's test and mean differences were declared at P=0.05.

Experiment 2 (SURVEY): Data was summarized in Minitab using graphical description statistics (Minitab® 15. 1. 30. 0, ©2007 Minitab Inc.) at P=0.05.

3.4. SURVEY PROCESS

In addition to colostrum assessment on one commercial dairy farm, 50 randomly selected commercial dairy farms in the same study area were surveyed by structured interview to assess the colostrum management practices followed by each dairy farmer in the study area. Only farmers with herds milking more than 250 cows of the Holstein or Holstein cross breed were included in this survey. Data were obtained by individually interviewing commercial dairy farmers using a questionnaire. The survey was conducted by the researcher and one assistant during the period 01 May 2010 to 31 October 2010.

The 3 most important aspects associated with colostrum management practices are the timing of the feed, the quantity of colostrum fed and the colostrum quality which could only be estimated by colostrometer assessment. The questionnaire was thus aimed at assessing the general compliance with the management of these factors by farmers in the Eastern Cape.

General principles in the design of the questionnaire were adapted from Kehoe *et al.* 2007 and Fulwider *et al.* 2008. The questionnaire included questions concerning milking procedures (hand milking, machine milking) and protocols (timing of separation from the cow) and calf feeding such as timing, volumes and feeding methods (bucket, esophageal force-feeding tube, nursing the cow). An example of the questionnaire is included in this document as appendix B.

3.4.1 DATA ANALYSIS OF SURVEY RESULTS

Following on from the study participants signing of a consent form (Appendix A), all the questionnaires were treated as confidential and particulars of the participants remain confidential. Each participant was informed in writing about the study and his/her right to withdraw at any time.

In the case of the questionnaire, the data were categorical and each answer was recorded. Simple data description was performed and the data were represented in the form of bar graphs and mean values. Additionally, factors that are known to influence Ig concentration i.e. the month of calving and parity, were recorded to compare these results. Mean values were calculated for all data. The probability that a cow had good quality colostrum (Ig of

50 mg/ml or more) was then calculated by regression model to compensate for colostral temperature variations (Kehoe *et al.*, 2007).

3.5. STATISTICAL ANALYSIS

Regression analysis was done on immunoglobulin (IgG) levels at temperatures measured immediately post milking and at 20°C using a model by *Mechor et al.*, (1992). This technique was used as a variation exists between colostrum SG and subsequent Ig content estimation when measured at different temperatures. This technique enables one to estimate and compare different colostrum samples from various animals, at different temperatures and treatments (frozen/thawed) for Ig content, on-farm, without laboratory analysis.

3.6. ETHICAL CONSIDERATIONS

3.6.1. DATA

All data obtained, from whatever source, were, at all times, handled with strict confidentiality. Written and signed informed consent was obtained from each questionnaire participant as well as the owner of the colostrum trial site. The questionnaires were not anonymous; however, the participant details are treated as confidential. Materials used during the course of the research posed no undue health risk to researchers and no animals were harmed in any way.

3.6.2. ANIMAL WELFARE CONSIDERATIONS

The study complied with Animal Welfare legislation and the requirements of the National Health Research Ethics Council under the National Health Act (2005). All animals remained in their usual farm environment. The nature of the study did not require any invasive and/or stressful actions to be performed.

The animals were assessed within their normal routine and conditions of herd management. Any non-routine management procedures during the study period were recorded. Conditions which required treatment would have been attended to by a veterinarian. The animals remained at the study site after completion of the study.

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CHAPTER 4

RESULTS: COLOSTRUM SAMPLING

4.1. INTRODUCTION

As multiple factors i.e. calving season, parity and colostrum temperature are known to influence the quality of colostrum the results will be presented separately in the 3 calving seasons that were investigated. The seasons that will be reported on are autumn (A), winter (W) and spring (S). This is to evaluate the effect of calving season on colostrum quality.

Further to the calving season the results will be subdivided into results per lactation number (L) from the 8 different lactations the evaluated cows represent i.e. L1 to L8. This to evaluate the effect of parity on colostrum quality.

The temperature at which colostrum is measured by colostrometer influences the SG of the specific colostrum sample and is indicative of colostrum quality. Therefore 3 readings will be reported on. *Reading 1* (CR1) represents the colostral SG immediately after collection and at variable temperatures. *Reading 2* (CR2) represents the colostral SG taken at room temperature (20°C). Colostrum samples were then frozen for 21 days immediately after reading 2. *Reading 3* (CR3) represents the colostral SG after it was naturally thawed to room temperature (20°C) after being frozen (21 days storage at -18°C).

Regression analysis was done as was described in section 3.7 and results will be presented and compared as LS mean colostrometer values. Regression calculation value 1 (Reg1) was calculated based on CR1, regression calculation value 2 (Reg2) was calculated based on CR2 and regression calculation value 3 (Reg3) was based on CR3. The results will be presented as tables.

4.2. QUALITY OF COLOSTRUM SAMPLES

Ninety colostrum samples were collected over a 6 month period from 01 May 2010 to 31 October 2010 and measured for colostrum quality (SG). These samples were recorded and plotted on a single Histogram (figure 4.1). The values represent CR2.

The standard for good quality colostrum is a SG reading >1.050 and an Ig value of more than 50 mg/ml (Fleenor and Stott, 1980; Mechor *et al.*, 1992; Tyler *et al.*, 1999a). All the samples above these parameters are of good quality and all the samples below these parameters are of poor quality. The colostrum sampling results were from the following sample sizes: autumn $n=18$, winter $n=42$ and spring $n=30$. Based on colostrometer reading only, 47 samples from 90 (52%) were below the 1.050 colostrometer value and considered to be of inadequate quality to ensure sufficient transfer of passive immunity.

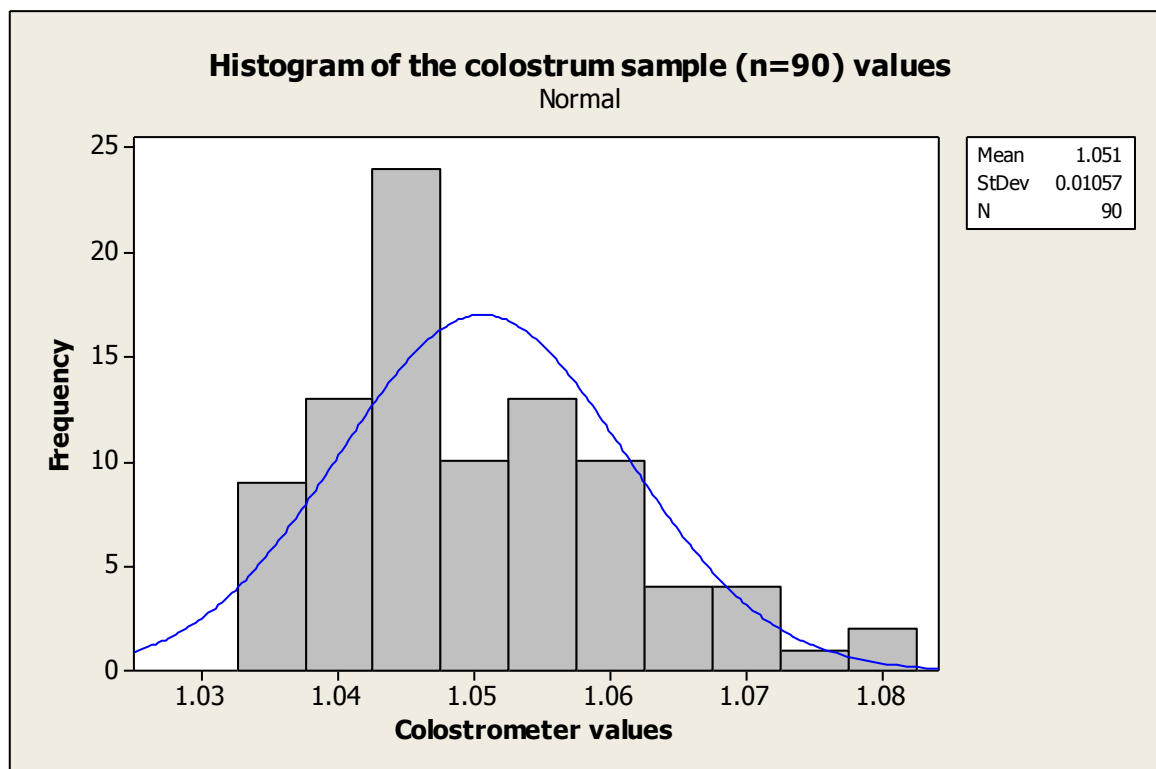


Figure 4.1: Colostrum values of 90 colostrum samples (x-axis), by colostrometer value at 20°C (CR2).

Of the 43 from 90 samples (48%) that exceeded the 1.050 colostrometer value, 10 samples (11%) were collected in autumn, 24 samples (27%) were collected in winter and 9 samples (10%) were collected in spring.

The $n=90$ samples had LS mean colostrometer reading of 1.051 with a standard deviation of ± 0.0105 .

4.3. AUTUMN CALVING SEASON

4.3.1. AUTUMN COLOSTRUM SAMPLE EVALUATION

Table 4.1 shows means of colostrum readings for cows calving in Autumn. The colostrum temperature at the first reading (CR1) varied from 34°C to 36.8°C with a mean temperature of 34.9°C; whilst the second and third reading (CR2 and 3) were done at 20°C. Colostrum measurements did not vary significantly ($P=0.164$) even though the samples were measured at varying temperatures. The colostrometer readings ranged from 1.044 to 1.051.

4.4. WINTER CALVING SEASON

4.4.1 WINTER COLOSTRUM SAMPLE EVALUATION

Table 4.2 shows means of colostrum readings for cows calving in Winter. The colostrum temperature at the first reading (CR1) varied from 34°C to 36.2°C with a mean temperature of 35.5°C; whilst the second and third reading (CR2 and 3) were done at 20°C. Colostrum measurements varied significantly ($P=0.011$). CR1 and CR2 were not similar. CR2 and CR3 and also CR1 and CR3 were similar. The colostrometer readings ranged from 1.031 to 1.080.

4.5. SPRING CALVING SEASON

4.5.1. SPRING COLOSTRUM SAMPLE EVALUATION

Table 4.3 shows means of colostrum readings for cows calving in Spring. The colostrum temperature at the first reading (CR1) varied from 34.1°C to 36.8°C with a mean temperature of 35.5°C; whilst the second and third reading (CR2 and 3) were done at 20°C. Colostrum measurements varied significantly ($P=0.021$). CR1 and CR2 were not similar. CR2 and CR3 and also CR1 and CR3 were similar. The colostrometer readings ranged from 1.030 to 1.070.

Table 4.1: AUTUMN colostrum reading (CR) LS means and standard deviation (Std Dev).

| Season | Parameter | Number (n) | LS Mean | Std Dev |
|--------|-----------|------------|---------|---------|
| Autumn | CR1 | 18 | 1.044 | 0.0076 |
| | CR2 | 18 | 1.051 | 0.0101 |
| | CR3 | 18 | 1.047 | 0.0112 |
| | | | P=0.164 | |

Table 4.2: WINTER colostrum reading (CR) LS means and standard deviation (Std Dev).

| Season | Parameter | Number (n) | Mean | Std Dev |
|--------|-----------|------------|---------------------|---------|
| Winter | CR1 | 42 | 1.046 ^a | 0.0107 |
| | CR2 | 42 | 1.053 ^b | 0.0121 |
| | CR3 | 42 | 1.047 ^{ab} | 0.0121 |
| | | | P=0.011 | |

*LS means with similar superscripts were not significantly different at $P < 0.05$

Table 4.3: SPRING colostrum reading (CR) LS means and standard deviation (Std Dev).

| Season | Parameter | Number (n) | Mean | Std Dev |
|--------|-----------|------------|---------------------|---------|
| Spring | CR1 | 30 | 1.042 ^a | 0.0071 |
| | CR2 | 30 | 1.047 ^b | 0.0076 |
| | CR3 | 30 | 1.044 ^{ab} | 0.0068 |
| | | | P=0.021 | |

*LS means with similar superscripts were not significantly different at $P < 0.05$

Table 4.4 clearly demonstrates that there was no statistical significant difference between the colostrometer readings across the three seasons. Additionally it appears that colostral quality was not lost when it was frozen.

Table 4.4: Variations in colostrum readings (CR) and standard deviations (Std Dev) across three (3) seasons.

| Season | Number (n) | CR1 | Std Dev (+/-) | CR2 | Std Dev (+/-) | CR3 | Std Dev (+/-) |
|--------|---------------|---------|------------------|--------|------------------|---------|------------------|
| Autumn | 18 | 1.044 | 0.0076 | 1.051 | 0.0101 | 1.047 | 0.0112 |
| Winter | 42 | 1.046 | 0.0107 | 1.053 | 0.0121 | 1.047 | 0.0121 |
| Spring | 30 | 1.042 | 0.0071 | 1.047 | 0.0076 | 1.044 | 0.0068 |
| | | P=0.204 | | P=0.07 | | P=0.425 | |

There was a tendency for variation within CR2 across seasons (P=0.07) probably due to the high variation in measurements (standard deviations).

4.5.4 LACTATION NUMBER (PARITY) OF COWS

Lactation number of cows (Parity):. Although parity had an influence on SG values of individual cows it was not statistically significant for the group. LS mean colostrometer readings for the 90 cows varied between 1.0456 to 1.0632 with P-Value (P =0.117).

Table 4.5: LS mean values/lactation number and standatd deviations (Std Dev), across seasons

| Parity (L) | Number (n) | Mean | Std Dev |
|------------|------------|---------|---------|
| 1 | 19 | 1.0501 | 0.0129 |
| 2 | 22 | 1.0495 | 0.0083 |
| 3 | 9 | 1.0513 | 0.0109 |
| 4 | 11 | 1.0456 | 0.0086 |
| 5 | 12 | 1.0538 | 0.0088 |
| 6 | 10 | 1.0490 | 0.0104 |
| 7 | 2 | 1.0470 | 0.0000 |
| 8 | 5 | 1.0632 | 0.0137 |
| | | P=0.117 | |

Season of calving: Table 4.1 (P=0.164), Tabel 4.2 (P=0.011) and Table 4.3 (P=0.021) shows that there were no significant differences in colostrometer readings between colostrum samples of cows across seasons. However there were also clear variations within the same season as can be seen in Table 4.2 and table 4.3. It is thus clear that in this study season of calving had a greater effect on SG values than lactation number.

This supports previous author's findings that the cooler month (winter) have superior SG values when compared to the hotter months (spring and summer).

Table 4.6 Shows a summary of the readings CR1, CR2 and CR3. LS means, SE Means, Maximum, Medians and Minimum CR readings are compared across seasons.

Table 4.6: Summary of descriptive statistics (CR1, CR2, CR3)

| Variable | Treatment | Number (n) | Mean | SE Mean | Minimum | Median | Maximum |
|---|-----------|---------------|--------|------------|---------|--------|---------|
| Colostrum reading 1 at first measure, variable temperatures | Autumn | 18 | 1.0443 | 0.00180 | 1.0330 | 1.0455 | 1.0600 |
| | Spring | 30 | 1.0420 | 0.00130 | 1.0350 | 1.0400 | 1.0650 |
| | Winter | 42 | 1.0459 | 0.00165 | 1.0310 | 1.0460 | 1.0720 |
| Colostrum reading 2 at second measure 20°C | Autumn | 18 | 1.0506 | 0.00237 | 1.0360 | 1.0515 | 1.0690 |
| | Spring | 30 | 1.0472 | 0.00138 | 1.0350 | 1.0460 | 1.0700 |
| | Winter | 42 | 1.0530 | 0.00186 | 1.0350 | 1.0520 | 1.0800 |
| Colostrum reading 3, at third measure, 20°C after thawed | Autumn | 18 | 1.0473 | 0.00263 | 1.0300 | 1.0450 | 1.0750 |
| | Spring | 30 | 1.0439 | 0.00124 | 1.0300 | 1.0450 | 1.0650 |
| | Winter | 42 | 1.0468 | 0.00187 | 1.0300 | 1.0450 | 1.0750 |

4.6. REGRESSION MODEL ESTIMATES OF COLOSTRUM QUALITY

4.6.1. INTRODUCTION

Regression model calculations enables one to compare results from samples taken at various temperatures (Mechor *et al.*, 1992).

4.6.2. REGRESSION MODEL FOR COLOSTRUM SAMPLES

Table 4.7 Shows LS mean regression estimates for cows calving in Autumn. The colostrum temperature at the first reading (CR1) varied from 34°C to 36.8°C with a mean temperature of 34.9°C; whilst the second and third reading (CR2 and 3) were done at 20°C. Regression estimates did not vary significantly ($P=0.330$) even though the samples were measured at varying temperatures. The Ig values ranged from 17.740 mg/ml to 60.850 mg/ml.

Table 4.8 Shows mean regression estimates for cows calving in Autumn. The colostrum temperature at the first reading (CR1) varied from 34°C to 36.8°C with a mean temperature of 34.9°C; whilst the second and third reading (Reg2 and 3) were done at 20°C. The Ig values ranged from 17.740 mg/ml to 60.850 mg/ml. There were significant differences among regression estimates ($P=0.012$), however Regression1 and Regression 2 were similar with Regression3 differing significantly from the two readings.

Table 4.9 shows mean regression estimates for cows calving in Autumn. The colostrum temperature at the first reading (CR1) varied from 34°C to 36.8°C with a mean temperature of 34.9°C; whilst the second and third reading (Reg2 and 3) were done at 20°C. The Ig values ranged from 17.740 mg/ml to 56.440 mg/ml. There were significant differences among regression estimates ($P=0.005$), however Regression1 and Regression 2 were similar with Regression3 differing significantly from the two readings.

Table 4.7: AUTUMN LS means of colostrum quality and standard deviation (Std Dev) based on regression model.

| Season | Parameter | Number (n) | LS Mean (mg/ml) | Std Dev |
|--------|-------------|------------|-----------------|---------|
| Autumn | Regression1 | 18 | 38.785 | 6.3960 |
| | Regression2 | 18 | 37.485 | 9.6430 |
| | Regression3 | 18 | 34.345 | 10.6880 |
| | | | P=0.330 | |

Table 4.8: WINTER LS means of colostrum quality and standard deviation (Std dev) based on regression model.

| Season | Parameter | Number (n) | Mean (mg/ml) | Std Dev |
|--------|-------------|------------|----------------------|---------|
| Winter | Regression1 | 42 | 40.260 ^a | 9.1600 |
| | Regression2 | 42 | 39.750 ^{ab} | 11.5700 |
| | Regression3 | 42 | 33.800 ^b | 11.6000 |
| | | | P=0.012 | |

*LS means with similar superscripts were not significantly different at $P < 0.05$

Table 4.9: SPRING LS means of colostrum quality and standard deviation (Std Dev) based on regression model.

| Season | Parameter | Number (n) | Mean (mg/ml) | Std Dev |
|--------|-----------|------------|----------------------|---------|
| Spring | Reg1 | 30 | 36.798 ^a | 6.1170 |
| | Reg2 | 30 | 34.186 ^{ab} | 7.2400 |
| | Reg3 | 30 | 31.056 ^b | 6.5280 |
| | | | P=0.005 | |

*LS means with similar superscripts were not significantly different at $P < 0.05$

Afterter calculation by regression model the samples with an Ig content considered to transmit sufficient passive immunity were 11% (10 from 90 samples) compared to 48% (43 from 90 samples) when measured by colostrometer. The results from the regression calculation of total colostral Ig varies markedly from that what was reported by Fleenor and Stott in 1980 and Mechor *et al.*, in 1992. This variation might partly be attributed to 46% (41 from 90) of cows that were of the first and second lactation. It is documented that lactation number affects colostral Ig and colostral fat content. In addition to this the colostral SG measurements were taken at approximately 37°C during the Fleenor and Stott research compared to 20°C in this study (Quigley and Martin, 1994).

Table 4.10: Variation in colostrum quality across seasons based on regression estimates.

| Season | Number (n) | Reg1 (mg/ml) | Std Dev (+/-) | Reg2 (mg/ml) | Std Dev (+/-) | Reg3 (mg/ml) | Std Dev (+/-) |
|--------|---------------|-----------------|------------------|-----------------|------------------|-----------------|------------------|
| Autumn | 18 | 38.785 | 6.3960 | 37.485 | 9.6430 | 34.345 | 10.6880 |
| Winter | 42 | 40.265 | 9.1620 | 39.751 | 11.5690 | 33.789 | 11.5980 |
| Spring | 30 | 36.798 | 6.1170 | 34.186 | 7.2400 | 31.056 | 6.5280 |
| | | P=0.179 | | P=0.07 | | P=0.425 | |

*There was a tendency for variation within Reg2 across seasons (P=0.07) probably due to the high variation in measurements (standard deviations).

Table 4.11: Summary of descriptive statistics (Reg1, Reg2, Reg3) across 3 seasons.

| Variable | Treatment | Number (n) | Mean | SE Mean | Minimum | Median | Maximum |
|--|-----------|---------------|-------|------------|---------|--------|---------|
| Regression 1 at first measure, variable temperatures | Autumn | 18 | 38.79 | 1.51 | 29.07 | 39.85 | 52.02 |
| | Spring | 30 | 36.80 | 1.12 | 30.49 | 35.22 | 56.44 |
| | Winter | 42 | 40.26 | 1.41 | 27.72 | 40.68 | 62.26 |
| Regression 2 at second measure 20°C | Autumn | 18 | 37.49 | 2.27 | 23.49 | 38.34 | 55.10 |
| | Spring | 30 | 34.19 | 1.32 | 22.53 | 33.07 | 56.06 |
| | Winter | 42 | 39.75 | 1.79 | 22.53 | 38.82 | 65.64 |
| Regression 3, at third measure, 20°C after thawed | Autumn | 18 | 34.35 | 2.52 | 17.74 | 32.11 | 60.85 |
| | Spring | 30 | 31.06 | 1.19 | 17.74 | 32.11 | 51.27 |
| | Winter | 42 | 33.80 | 1.79 | 17.74 | 32.11 | 60.85 |

CHAPTER 5

RESULTS: COLOSTRUM QUESTIONNAIRE

5.1. INTRODUCTION

During the period 01 May 2010 and 31 October 2010 a colostrum survey involving the completion of a questionnaire, was conducted in the study area. The survey was conducted on a face to face basis (interview) and hence a 100% reply rate was obtained. Whilst conducting the survey 22 questions were posed to 50 leading dairy farmers within the study area. This colostrum survey reports on colostrum management practises of these commercial dairy farms, each of which have >250 lactating dairy cows at any point in time. The total number of lactating cows represented in this survey is approximately 33,000 and approximately 11,625 heifer calves are reared on these farms annually. The results of the questionnaire are represented by bar graphs.

5.2. SURVEY (QUESTIONNAIRE) RESULTS

Questions are represented as a topic and question number i.e. Colostrum (Q1)

Choice of breeds (Q1):

This question required the participants to select their breed of dairy cattle. The major breeds within the study area are Holstein and Jersey cattle. 10 out of 50 farms (20%) were farming purebred Holstein cattle, 2 out of 50 farms (4%) farm with purebred Jersey cattle and 4 out 50 farms (8%) farm with purebred cattle of both breeds. However, the results indicated that the trend, 34 out of 50 farms (68%), in the Eastern Cape Province was clearly shifting towards farming with crossbred (Holstein/Friesland X Jersey) dairy cattle.

Herd size of farms (Q2):

The herd size of the farms that participated in the survey is represented in Figure 5.1. 44% milk >400 cows, 6% milk between 401-500 cows, 32% milk between 501-1000 cows, 14% milk >1000 cows and 4% milk >2000 cows at any point in time.

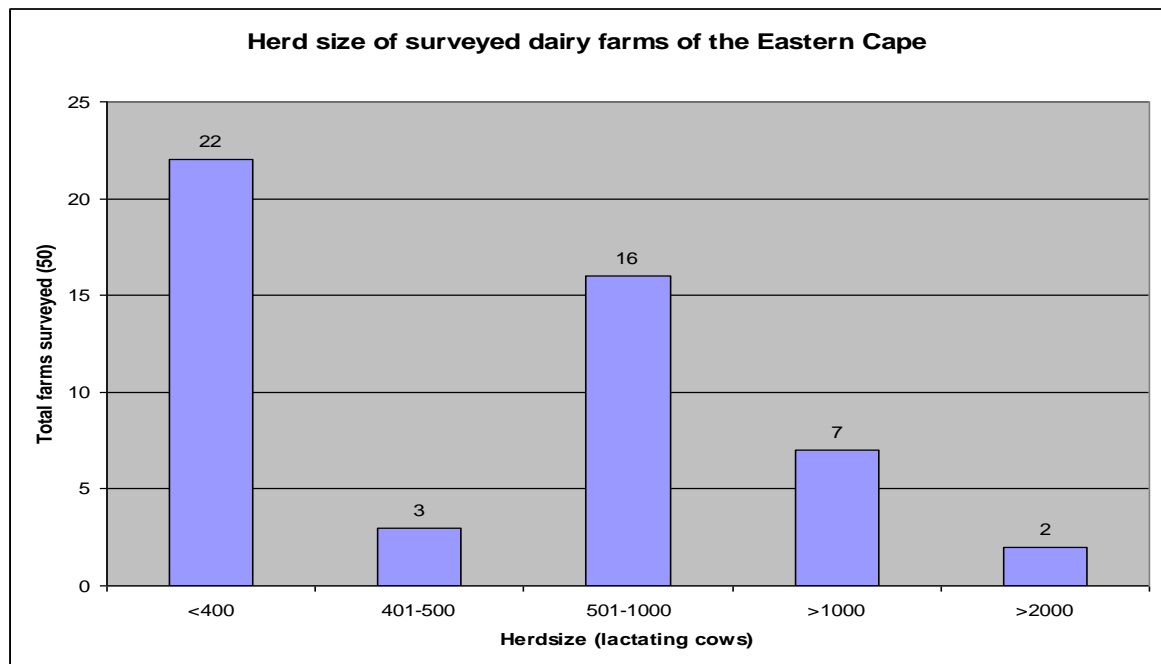


Figure 5.1: Herd size of surveyed dairy farms

Birth weight of calves (Q3):

The birth weight of dairy calves in the study area is represented in figure 5.2. 52% of the farms surveyed had an average birth weight of between 36 kg - 40 kg, 42% had an average birth weight of 30 kg - 35 kg and 6% have calves weighing in at >40 kg at birth.

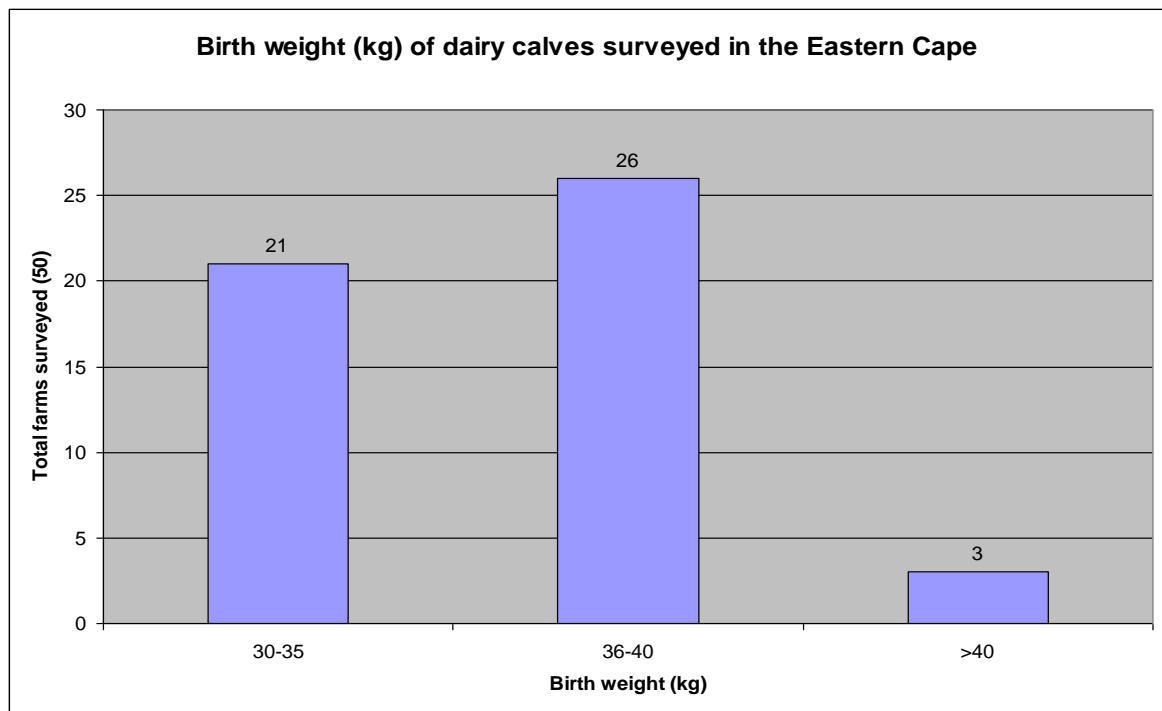


Figure 5.2: Birth weight (kg) of dairy calves.

Distribution of calves on farms (Q4):

The Histogram in Figure 5.3 represents the number of heifer calves reared annually per surveyed farm in the study area. The 50 dairy farms surveyed raise approximately 11,625 heifer calves annually. The annual mean is 232 heifer calves/farm, the median is 350 with a mode of 80.

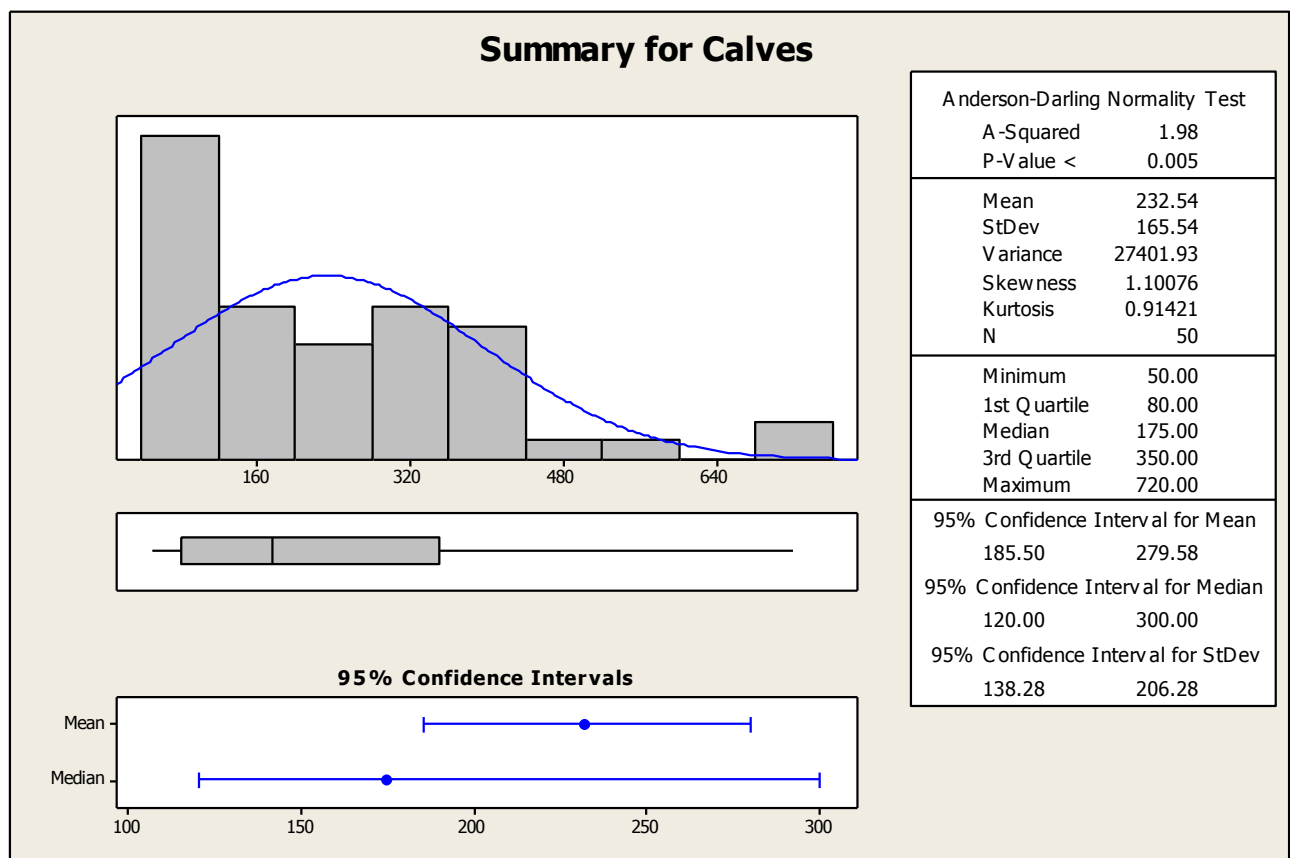


Figure 5.3: Number of calves reared.

Timing of separation from the dam (Q5):

The timing of the separation of the calf from its dam is represented in figure 5.4. 60% of dairy farmers in the study area separate their calves from their dam's immediately upon birth, day (D0). This is a good practice as the calf has less exposure to environmental pathogens with this practice. 38% separate calves at between D3-D5, 2% separated calves at D7 and 0% had calves suckling their dams at >D7.

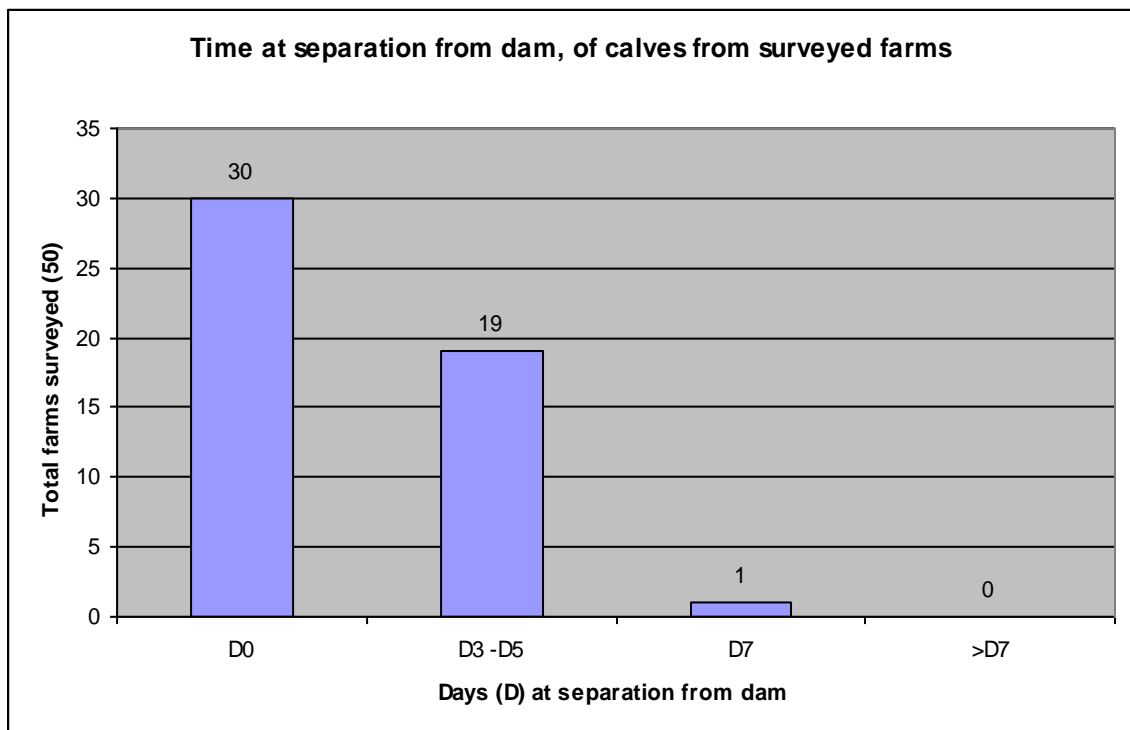


Figure 5.4: Timing of separation of calves from the dam

Colostrum management:

Only 10% of surveyed farmers were able to accurately define colostrum as the mammary excretion from the first milking (Q6) whilst only 4% measure colostrum prior to their feeding it to newborn calves. Thus 96% feed colostrum of undefined measure (Q7). The 2 farmers that measured colostrum SG quality used a commercially available colostrometer (Q8). The manufacturer/s of the colostrometers used by the 2 farmers is unknown.

Method of colostrum collection (Q9):

The methods farmers use to collect colostrum in the study area are represented in figure 5.5. After not allowing the calf to suckle either hand or milking machine harvesting of colostrum is acceptable, however the quick post calving harvesting is the most critical factor with regards to quality and quantity of colostrum. 37 out of 50 farms collect colostrum by machine milking the cow, 11 out of 50 farms allow cows to nurse their calves and 2 out of 50 farms hand milk the cow to collect colostrum.

Method of collecting colostrum on dairy farms of the Eastern Cape

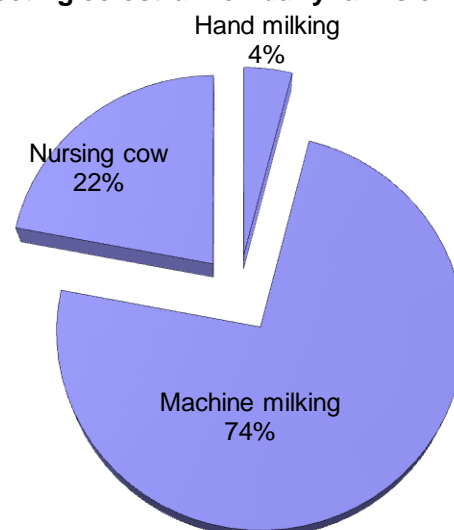


Figure 5.5: Methods of collecting colostrum.

Method of colostrum feeding (Q 10):

The methods farmers use to feed colostrum to calves in the study area are represented in figure 5.6. 38 out of 50 farms feed colostrum by bucket or teat method, 11 out of 50 farms allow cows to nurse their calves and 1 out of 50 farms use the force-feed method to ensure colostrum uptake by the newborn calf.

Method of colostrum collection

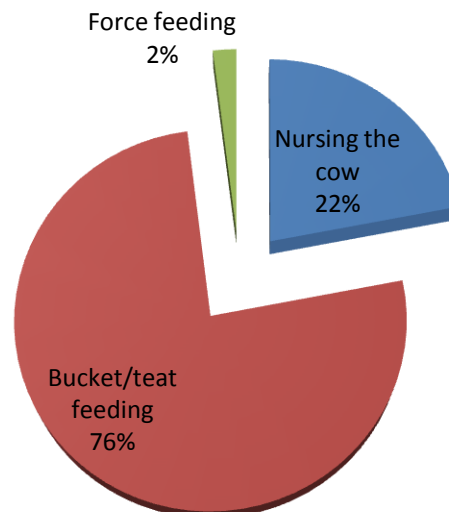


Figure 5.6: Methods of feeding colostrum.

Colostrum volume fed to calves (Q11):

The amount (L) of colostrum fed to dairy calves in the study area is represented in figure 5.7. 56% of dairies feed between 2L-4L of colostrum/calf, 22% feed 2L of colostrum /calf, 22% allow cows to nurse their calves (>8) and 0% feed 4L-6L and 6L-8L of colostrum respectively.

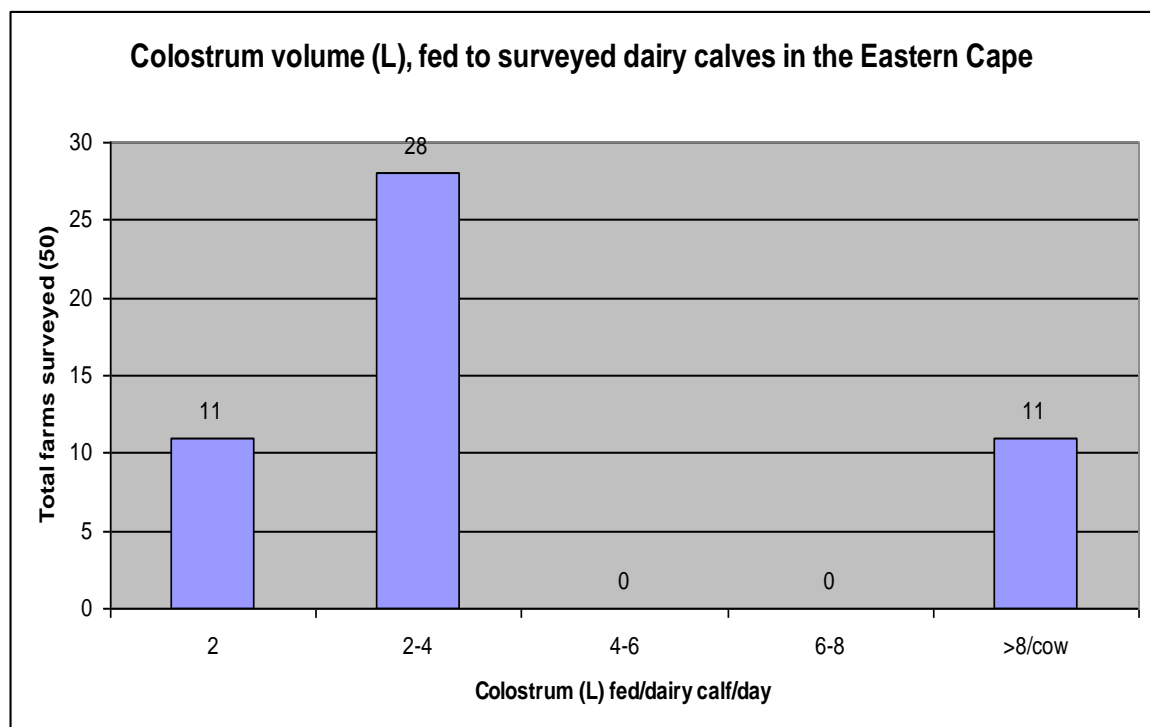


Figure 5.7: Colostrum volume (L) fed.

Timing of the colostrum feed (Q12):

The timing of the first colostrum meal, post-partum, to dairy calves in the study area is represented in figure 5.8. Fifty two percent of the farmers feed the first colostrum <6 hours post-partum, 26% feed colostrum at between 6-12 hours post-partum, 20% allow calves to nurse their dams from D(0) to maximum D(7), 2% feed colostrum between 18-24 hours and 0% feed colostrum at between 12-18 hours and >24 hours post-partum respectively.

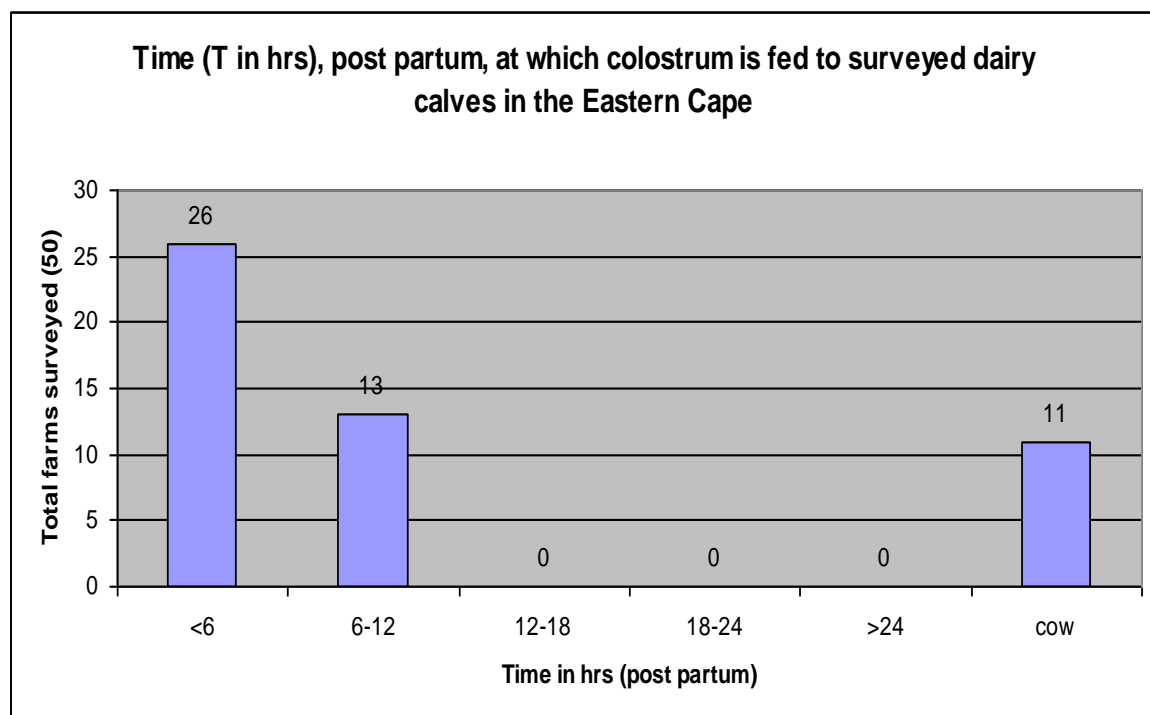


Figure 5.8: Time (T in hrs) post-partum, at which colostrum is fed.

Follow up (Y or N) of the initial colostrum feed (Q13):

Figure 5.9 indicates whether or not farmers follow up the initial colostrum meal fed post-partum to dairy calves in the study area. 39 out of 50 farms do not follow up the initial colostrum meal whilst 11 out of 50 farms follow up on the initial colostrum meal at various timings (see figure 5.10).

Follow up of the initial colostrum meal in surveyed dairies of the Eastern Cape

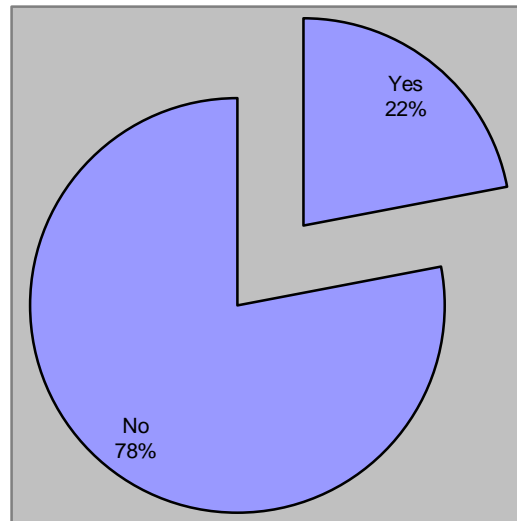


Figure 5.9: Follow up on the initial colostrum meal.

Timing of the follow-up colostrum meal (Q14):

The timing of the follow up feeding of calves in the study area is represented by figure 5.10. Seventy eight percent do not follow up the initial colostrum feed, 16% follow up at T + 18 hrs, 4% follow up at T + 12 hrs and 2% follow up at T + 6 hrs after the initial colostrum meal <6 hrs post-partum.

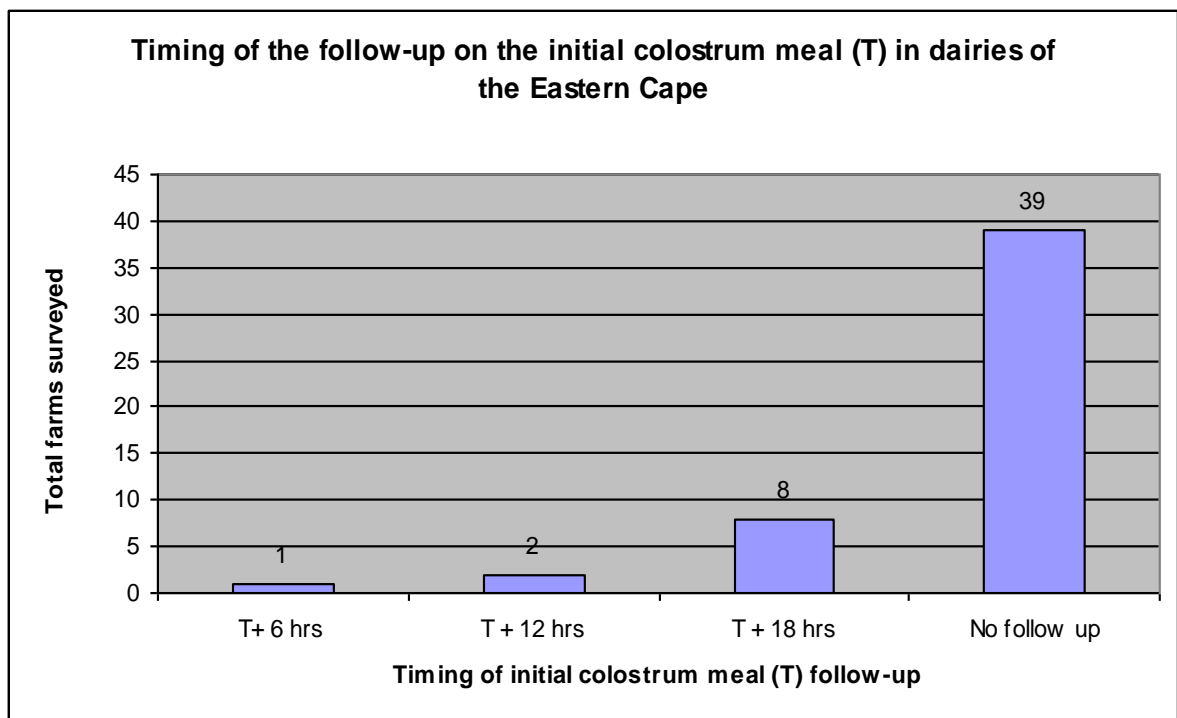


Figure 5.10: Timing of the follow up on the initial colostrum meal (T).

Alternative forms of colostrum (Q15):

The alternative forms of colostrum fed to dairy calves in the study area are represented by figure 5.12. Ninety six percent do not make use of any alternative form of colostrum such as frozen, pooled or fermented colostrum, 2% feed pooled colostrum, 2% feed frozen colostrum and 0% feed fermented colostrum.

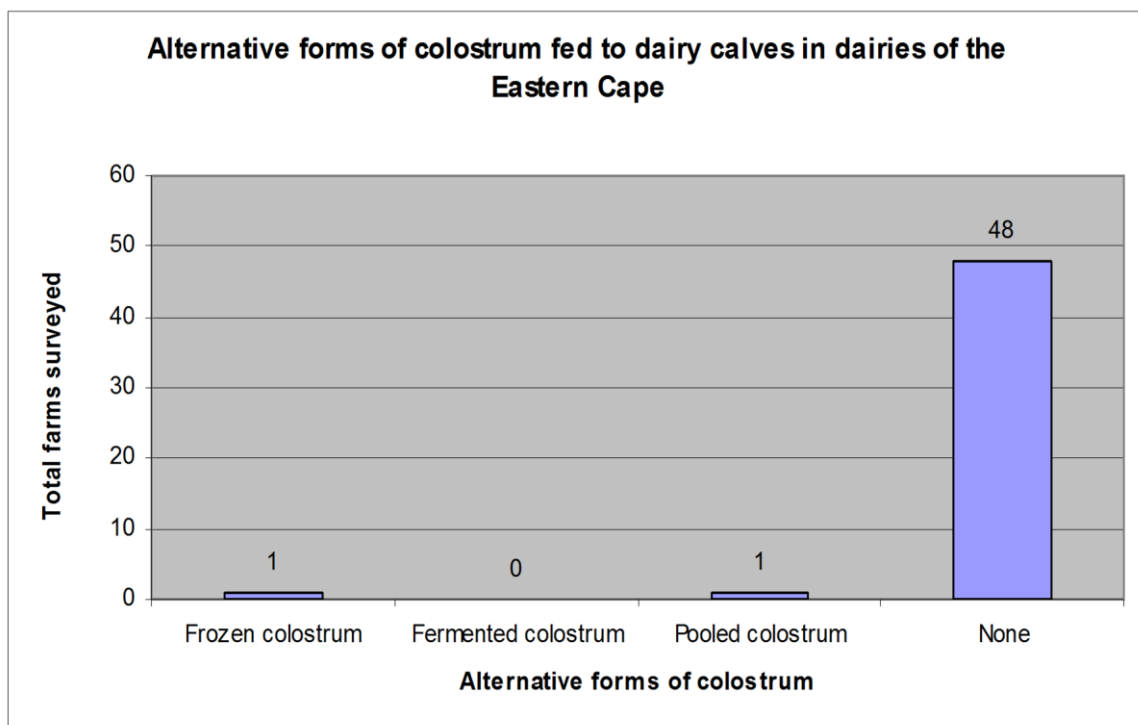


Figure 5.11: Alternative forms of colostrum fed to dairy calves

Milk feeding practices

All surveyed farms had a milk feeding periods of between 42-60 days (Q16) and reared calves on milk replacers (Q17). The calves were fed between 2L-4L of milk/feeding/calf, twice a day (Q18). About 70% of farmers from this study area house their calves indoors post calving and 30% house their calves outdoors (Q19).

Major on-farm diseases (Q20):

The major prevalent calf diseases, as confirmed by veterinary diagnosis, in dairies of the study area are represented in figure 5.13. 36% of farms experienced *E.coli* infections, 24% of farms experienced *Salmonella* spp. infections, 34% of farms experienced *Eimeria* spp. infections, 46% of farms experienced *Pasteurella* spp. infections and 22% of farms experienced other causes of newborn morbidity and/or mortality such as dystocia etc.

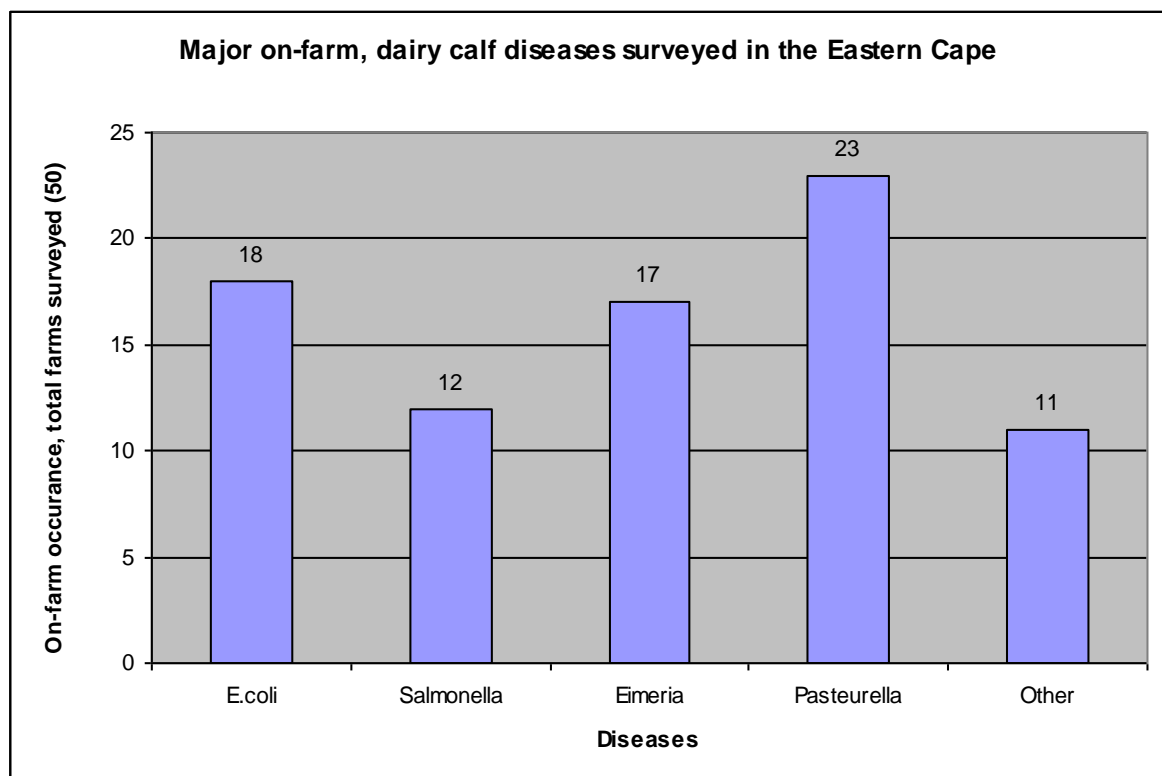


Figure 5.12: Major on-farm, dairy calf diseases.

Mortality rate (Q21):

The mortality rate experienced amongst newborn dairy calves on farms in the study area is represented in figure 5.14. 16 out of 50 farms have a mortality rate of <5%, 26 out of 50 farms have a mortality rate of between 5%-7.5% and 8 out of 50 farms have a mortality rate of >7.5%. A positive correlation between mortality rate and management practices could not be established in this study as the mass of colostrum fed by farmers is up to standard, however colostrum quality which plays a major role is not measured by 48 out of 50 farmers (96%)(question 7).

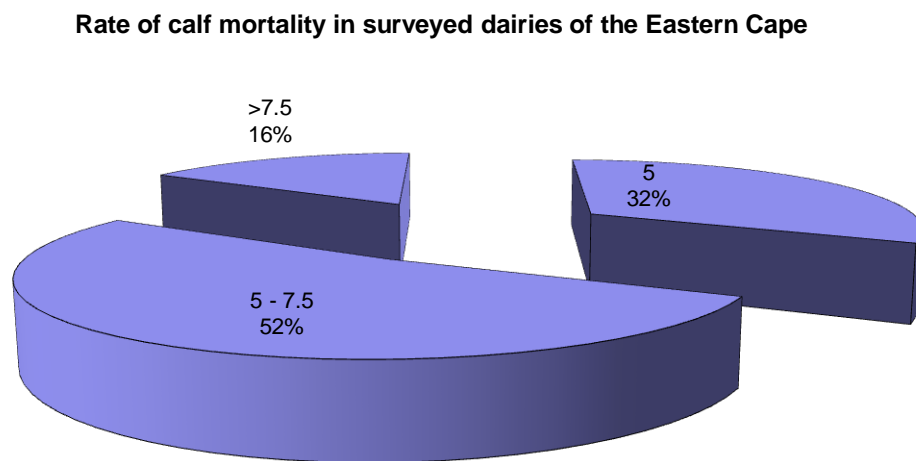


Figure 5.13: Rate of calf mortality (%).

Pathogen ID (Q22):

Only 4 from 50 farms (8%) reported that they do post mortem pathology on their own accord. Veterinary diagnoses on all farms in the study area are associated with laboratory confirmation of the major calf diseases. However, not every case is attended to by a veterinarian.

CHAPTER 6

DISCUSSION

6.1. INTRODUCTION

The management of on-farm colostrum practices is a critical determinant of calf health, growth and future productive potential of the neonate. Several factors are known to be associated with colostral Ig transfer to neonates. Most important still remains the mass of colostrum i.e. volume and Ig concentration of the colostrum ingested. Recent reports published by the National Animal Health Monitoring System (NAHMS, 2007) supported by other publications (Godden, 2008) strongly suggest that opportunities for improvement related to passive transfer of immunity and management of colostrum practices exist in South Africa and worldwide. This study was adapted to highlight those management factors that would assist the farmers in optimizing the acquisition of passive immunity of their neonates calves.

6.2. COLOSTRAL SG VALUES

This study aimed at estimating the Ig concentration of colostrum fed to neonates by making use of an inexpensive on-farm colostrometer evaluation method (objective 2). Colostrum with an SG measurement between 50 mg/ml and 60 mg/ml or more was considered to be of good quality and, when fed to newborn calves in adequate quantities within 6 hours post-partum would be considered to have effectively transmitted enough immunoglobulins to produce sufficient passive immunity within the neonate.

In this study the Ig concentration was categorized into 3 categories (poor, moderate and excellent). The reason is two-fold; (1) It is of practical consideration to encourage the dairymen to evaluate colostrum quality prior to feeding, and enables him/her to identify and store excess good quality colostrum by i.e. freezing, and (2) a colostrometer estimates Ig based on the linear relationship between SG and colostral Ig, not by direct measure. It is, hence less likely that the colostrometer will give a biased result between multiple categories compared to a single Ig reading (Shearer *et al.*, 1992). Previous analyses of colostrometer readings (SG values) from first-milking colostrum samples of Holstein dairy

cows from a single dairy situated in the Eastern Cape Province Coastal region of South Africa indicated that colostral SG was influenced by external factors such as lactation number (parity), the month of calving and colostral temperature (objective 3). During this study it found that there were variations in colostral SG between different parities, however, it was not of statistical significance in the group $n=90$ and it was clear that colostral quality of cows that calved in the cooler of the three month's (winter) had greater colostrometer readings when compared to colostrum from cows that calved in the hotter of the three month's months i.e. spring. Winter LS mean of CR2 was 1.053 ($P=0.011$) when compared to Spring LS mean of CR2 which was 1.047 ($P=0.021$). Furthermore, the higher the temperature of the colostrum samples at measurement the higher the corresponding Ig value for the same sample i.e. CR1 for a specific sample had a greater value than CR3 of the same sample (McGuire *et al.*, 1976; Fleenor and Stott, 1980; Mechor *et al.*, 1992).

As in the Swedish study by Liberg in 2000 this study demonstrated differences in SG values among individual cows within the same breed, parity and calving season.

6.2.1. LACTATION NUMBER

When evaluated on colostrometer reading only the effect of parity (L) reported in this study is consistent with reports from earlier studies that cows in their first and second lactation have lower colostral SG values when compared to cows in 3rd and later lactations. Results of this study reports raw mean SG values of 1.050 for L1 and L2 compared to raw mean SG values of 1.052 for L3 to L8. (Oyenini and Hunter, 1978; Devery-Pocius and Larson, 1980; Pritchett *et al.*, 1991; Shearer *et al.*, 1992; Jardon *et al.*, 1998 and Tyler *et al.*, 1999). This leads to conclude that only good quality colostrum from cows in their 3rd or later lactation should be used when feeding newborn calves to ensure the optimal transfer of passive immunity (Muller and Ellinger, 1981; Hunt, 1990; Corbett, 1991, Piccione *et al.*, 2009). However, statistical analysis showed no significant variance between parities ($P=0.117$).

6.2.2. CALVING SEASON

In this study the effect of month of calving had a much greater influence on mean colostral SG values than lactation number. Mean colostral SG values demonstrated that winter SG values was superior when compared to spring SG values as was demonstrated by section

6.2. This is consistent with results by Shearer *et al* in 1992 and Morin *et al.* in 1997 that colostrometer readings of colostrum in cooler months tend to be greater than those from the hotter months. However, it is in contrast with findings from Pritchett in 1991 that season of calving had not a significant influence on Ig concentration of colostrum.

This occurrence of seasonal influence on colostral Ig concentration is often attributed to heat stress. Increased ambient temperature, humidity and increased body temperature increase cow discomfort and depresses the immune system. A depressed immune system is negatively correlated with colostrum quality (Ig) (Davis and Drackley, 1998). Milder temperatures are more conducive to cow comfort and this suggests that more attention should be given to the month of calving rather than the lactation number when colostral SG values are interpreted. The reasoning is that every colostrum sample can be measured by colostrometer irrespective of parity, however little can be done to avoid heat stress when cows calve down during a hot season.

6.2.3. COLOSTRAL TEMPERATURE

Instructions for use of a colostrometer suggest that colostrum be evaluated at 20°C. In this study colostrum was measured at three (2) different temperatures (immediately after harvesting, at 20°C and again at room temperature (20°C) after being thawed). There were no variations between colostral SG (CR1-CR3) for Autumn ($P=0.164$) as shown in Table 4.1. There were however statistical significant differences between colostral SG (CR1-CR3) for Winter ($P=0.011$) as shown in Table 4.2 and Spring ($P=0.021$) as shown in Table 4.3. These results confirm that colostral temperature does have an influence on mean colostral SG values. The higher the temperature (CR1) at which the colostrum sample is measured at, by colostrometer, the lower the mean SG values would appear to be. These results were similar to those obtained by Mechor *et al.* in 1992 and Shearer *et al.* in 1992, and support the statement that the mean SG values of samples measured at temperatures above 20°C are often under-estimated. The lower mean SG values of the frozen and then naturally thawed samples demonstrates that there is a slight loss of Ig content, over time, when colostrum is stored however not statistically significant as shown by Table 4.4 CR3 reading ($P=0.425$). It can hence be concluded that colostral SG measured at temperatures higher than 20°C will likely underestimate Ig concentration.

6.2.4. COLOSTRUM RESULTS FROM THE STUDY AREA

From the results of the colostrum evaluation study it would appear that the colostrum quality of the trial site is of inadequate quality. A regression model allows for comparison of colostrum samples whilst taking into consideration possible variables (temperatures). The standard for Ig concentration is 50mg/ml Ig. After calculation by regression model of CR1 (raw) the results demonstrated that only 9 from 90 colostrum samples (10%) that were evaluated had a Ig concentration of >50 mg/ml IgG. This result is consistent with international research described by Shearer and co-workers (1992), where only 137 from 2045 cows (6.7%) produced colostrum of quality exceeding 50 mg/ml Ig. When the regression model was applied to CR2 (raw) only 10 from 90 colostrum samples (11%) that were evaluated had an Ig concentration of >50 mg/ml IgG. Such results support the possibility of FPT at the trial site and it explains the above acceptable mortality rate of >7.5% on this trial farm. This is supported by statistical analysis as shown in Tables 4.7 (P=0.330), 4.8 (P=0.012) and 4.9 (P=0.005). As shown in these tables all LS mean regression estimate values fall below the require 50 mg/ml Ig required for sufficient passive transfer of immunity. An acceptable rate of mortality is 5%. This trend is consistent with reports from the NAHMS in 2002 that approximately 9% of dairy heifers born in the USA died prior to weaning and that approximately 62% of all pre-weaned mortalities could be attributed to calf diarrhoea. Despite substantial research efforts the national average of calf mortalities still remains between 7%-8% annually (NAHMS, 2002).

6.3. COLOSTRUM QUESTIONNAIRE

6.3.1. INTRODUCTION

This study aimed at surveying and recording methods used for colostrum management in the study area (objective 1). Several factors are known to be associated with and subsequently influence the passive transfer of colostral IgG to the neonate. Most important is the mass (Volume and IgG concentration) of IgG ingested (Kruse, 1970a). A linear relationship exists between colostral SG and IgG concentration (Fleenor and Stott, 1980).

The colostrum questionnaire aimed to assess the management practices on dairy farms in the Eastern Cape Coastal region. During the survey twenty two (22) question were posed to 50 leading dairy farmers of the study area. These farms represent approximately 33,300

lactating dairy cows and approximately 11, 625 newborn heifer calves are reared by them annually, as was demonstrated by question 4 of the colostrum questionnaire.

6.3.2. QUESTIONNAIRE RESULTS

The colostrum questionnaire demonstrated in question 1 that the trend of breed choice in the Eastern Cape Coastal region is moving steadily from milking purebred herds to milking herds consisting of crossbred cows (most popular cross is Holstein/Friesland X Jersey). This strategy is aimed at increasing bulk milk solids to support the buying criteria of the milk buyers which are shifting from paying premium prices for milk volume to paying premium prices for milk solids. This strategy can be seen as positive as it unknowingly supports research by Pritchett *et al.* (1991) who reported that high milk volumes might decrease the weight of colostrum and subsequently the Ig concentration of colostrum as high milk volumes might have a dilution effect on the Ig in colostrum.

The number of commercial herds in the Eastern Cape Coastal region is on the decline from 717 in 1997 to 387 in January 2009 (MPO – Lacto data, 2010). However the remaining herds are growing in size when compared to the national average mean of 349 cows and median of 200 cows in South Africa (MPO – Lacto data, 2010). 56% of the commercial dairy herds in the study area milk < 400 lactating cows (figure 5.1).

Dystocia is a predisposing factor of FPT. 52% of farms surveyed from the study area produce newborn calves of between 36 kg to 40 kg (Figure 5.2). These birth weights reported are well within the range of < 42kg as recommended for Holstein cows to minimize dystocia.

60% of farms from the study area are separating calves from their dams immediately rather than allowing them to nurse from their dams (Figure 5.4). This is a good practice as it minimizes the exposure to environmental pathogens post-partum.

From the questionnaire's question 11 it would appear that most dairy farmers from the study area that were interviewed do not feed adequate quantities of colostrum (figure 5.7). None (0) of the commercial dairy farmers interviewed feed more than 4L of colostrum per calf; this represents approximately 50% of what is suggested by Kruse in 1970 (b) and again by Arthington in 2001. Furthermore, only 2 of 50 farmers interviewed measured the

quality of colostrum fed to calves by use of a colostrum densimeter as demonstrated by question 7 and 8, of the questionnaire. 52% of farmers feed colostrum <6 hours after calving and 26% of farmers feed colostrum between 6 to 12 hours after calving (Figure 5.8). Whilst this is acceptable, 78% of the farmers do not follow up on the initial colostrum meal (Figure 5.9). These practices are a serious risk to the mass of IgG that is potentially ingested by the neonate, supporting the elevated mortality rate of >5% on 68% of farms in the study area (Figure 5.13). From the survey it is evident that all of the surveyed commercial dairy farms suffered from the 3 major syndromes associated with neonates as described in the literature review. The problem statement of this study suggests that an inadequate mass of colostrum (quantity, quality) might be fed to newborn dairy calves of the study area. A direct consequence of this is elevated morbidity and mortality of neonates.

Alternative sources to natural colostrum such as fermented and commercially produced colostrum containing products have been investigated by numerous authors (Francisco and Quigley, 1993; Mee *et al.*, 1996; Morin *et al.*, 1997). Additionally several commercially available additives to natural colostrum failed to improve passive transfer of IgG, this is attributed to low IgG concentrations and poor absorption kinetics (Haines *et al.*, 1990), hence the critical importance of on farm colostrum management practices. Farmers from the study area do not make use of alternative sources of colostrum as these alternative forms are not commercially available in South Africa. However, 1 farmer out of 50 (2%) feed pooled colostrum and 1 farmer out of 50 (2%) feed frozen colostrum (Figure 5.11). It is imperative that calves are fed good quality colostrum quickly to ensure that they ingest sufficient immunoglobulins for passive immunity.

6.4. PRACTICAL CONSEQUENCES

The wide range of variations found in colostrum Ig concentrations, among different cows within a restricted area, is a common result found in the majority of research done on colostrum quality, including this study. These individual variances make drawing conclusions and doing recommendations with regards to risk factors which impact on colostrum quality very difficult.

Because most dairy farms of the study area feed fixed volumes of colostrum it is a very important factor to get the quality of such fixed volumes of colostrum exactly right to

ensure the sufficient transfer of passive immunity. The study area clearly demonstrated inferior on-farm colostrum quality. Additionally and it can be implicated, from the colostrum management survey results, that the farms from the study area will also have questionable colostrum quality. Having said that none more so than reported in studies and research worldwide. From the results it can be said that South African farmers' management practices results in figures similar to those of farmers of international research presented in this work. Because of these findings this study indicates a need to control colostrum quality control of newborn calves in the study area.

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CHAPTER 7

CONCLUSION

Colostrum is the first secretion from the cow's mammary gland post-partum. It is an important source of immune and nutritional factors for the newborn calf.

Rearing healthy dairy heifers with minimal mortality and clinical morbidity is crucial as a success factor in a dairying operation. Often mortality rates can be more than 5% on any given farm. 68% of farms surveyed in this study have a mortality rate of >5%, of which 16% is more than 7.5% (Figure 5.13). Dairymen should not be satisfied until mortality rates are <5%. The period between birth and weaning is the most crucial in the heifers' life.

A major management tool for reducing health problems in newborn calves is the feeding of the dam's colostrum. Inadequate passive transfer of immunoglobulins (FPT) poses a serious risk and is unfortunately a common occurrence in dairy calves - worldwide, hence the need for intervention to ensure adequate colostrum ingestion, thereby achieving a protective level of 10mg/ml serum IgG in dairy production. There are 3 reasons for FPT:

1. The colostrum fed was of inadequate **quality** (SG of <1.050).
2. The colostrum fed was of inadequate **quantity** (< 4L within 6hrs and/or < 8L within 24hrs post-partum).
3. Initial colostrum feeding did not come **quick** enough (within 1hr, then a follow up within 6hrs and a final feeding within 24hrs)

Evidence suggests that the concentration of Ig in colostrum decreases by 3.7% per hour from the time a cow has calved, therefore quick first milking and feeding of sufficient quantity, quality colostrum contributes to the successful transfer of passive immunity (Morin et al., 2010). The author of this study refers to the "trio Q" - quick (Q3) ingestion and absorption of adequate quantity (Q2) and quality (Q1) colostrum is critical for the health and survival of newborn calves.

From this study it can be said that the majority of dairies surveyed in the study area were making a substantial effort to feed colostrum quickly (Q3). However, no effort is being

made to determine the quality (Q1) of colostrum fed or to ensure the ingestion of optimal quantities (Q2) of colostrum.

Although lactation number and month of calving are external factors that influence colostral SG values, it is evident from this study that, of these factors, the month of calving has the greatest influence on colostral SG values.

The results of this study demonstrate the importance of monitoring colostrum quality, especially in dairy operations which practise the hand/bucket feeding method of pre-determined volumes of colostrum, for the purpose of optimizing passive immunity. From this study it would appear that intervention for colostrum ingestion is needed to achieve optimal protective serum levels of IgG.

The following recommendations are made in an attempt to minimize the risk factors associated with poor transfer of passive immunity to neonates (objective 4):

1. Neonates should be separated from the dam immediately post-calving. This will minimize the risk of colostrum contamination and reduce the time of neonate exposure to environmental pathogens that can result in clinical neonate disease.
2. Cows should not be allowed to nurse their calves. This will ensure quick ingestion of quality and quantity colostrum by teated – bucket/bottle feeder or esophageal feeder – “trio Q”.
3. Only “true” colostrum from the very first milking, immediately after calving should be fed. Use only colostrum that was milked from a sanitized udder. Discard bloody or mastitic colostrum. All subsequent milk is transitional milk with nutritional value rather than value to immunity.
4. Superior colostrum from the 3rd lactation and older cows is considered should be used for feeding of neonates. These cows were exposed to more pathogens through their lifetime resulting in superior antibody content of their colostrum.
5. A colostrum densimeter should be used to estimate colostrum quality, this will ensure that only good quality colostrum is fed to neonates. Measure the colostrum SG value at room temperature (approximately 20°C). Colostrum values of greater than 50 mg/ml IgG is of good quality.

6. Excess good quality colostrum should be pool and/or frozen for later usage This will ensure a constant supply of good quality colostrum when good quality fresh colostrum is unavailable or in short supply.
7. At least 4L good quality colostrum should be fed to a newborn calf within 1 - 6 hours (maximum) after calving and then followed –up with an additional 2L - 4L good quality colostrum before 12 hours after calving. Totaling 8L colostrum within the first 24hrs of life. After 24hrs post-calving – no absorption of Ig and colostrum will only serve a nutritional value.
8. The volume of colostrum fed should be increased if colostrum of good quality is in short supply. This will increase the mass of Ig fed to the calf.
9. Extra care should be given to calves born from dystocia and difficult births. These calves' immune response will be compromised due to stress. Additional colostrum should be fed as a precautionary measure.
10. Staff members should be adequately trained. This will make the process of colostrum management much more efficient.

With so many obvious benefits to the calf from feeding colostrum, making the choice to feed superior colostrum and have sound on-farm colostrum feeding protocols should be easy. Not only will calves be healthier but they will have the added benefit of high quality nutrition, beneficial growth and maturation.

It can hence be concluded that the hypotheses of this study that the quality of colostrum fed to dairy calves on the trial site and the colostrum management of the 50 assessed commercial dairy farms in the trial area is inadequate have been proven.

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APPENDICES

APPENDIX A

COLOSTRUM SURVEY PARTICIPANT CONSENT FORM

Colostrum questionnaire (interview) consent form.

Title: Survey of colostrum quality and management practices on commercial dairy farms in the Eastern Cape Province of South Africa

Researcher: The principle investigator is *Barry Schoombee*, P O Box 5248, Rietvallei Rand, 0174, Pretoria. Mobile phone: 079 8809 549. E-mail: agric.consult@lantic.net

Reason for research: This survey/questionnaire will be used for the purpose of partial fulfillment of a research study for the completion of a *Master of Science in Agriculture degree*.

Detail of participation: The research involves participating in completing a questionnaire. The duration is between 10-15 minutes.

Disclaimer: All information supplied by participants, during this interview, will at all times remain *confidential*.

Consent statement:

1. I understand that my participation is voluntary and that I may withdraw from the research at any time, without giving a reason.
2. I understand that there are no risks involved in the participation of this study.
3. I have had the opportunity to consider the information and all questions that I have about the research have been satisfactorily answered.
4. I am aware what my participation involves.
5. I agree to participate.

Signature:.....

Participant details:

Name:.....

Farm:.....

Address(postal):.....

Tel/cell:.....

Email:.....

Please select if you would like to receive a summary of the results by e-mail.

| | |
|-----|----|
| Yes | No |
|-----|----|

*Please select if you would like to remain **anonymous** or may your information be **published**.*

| | |
|----------------------------|------------------------|
| I wish to remain anonymous | I will allow publicity |
|----------------------------|------------------------|

Signature:.....

APPENDIX B

COLOSTRUM QUESTIONNAIRE - SURVEY

1. Select breed (please tick):

| | | | | |
|----------|--------|----------|----------|--------------------|
| Holstein | Jersey | Guernsey | Ayrshire | Crossbred or other |
|----------|--------|----------|----------|--------------------|

2. Select herd size (please tick):

| | | | | |
|------------|--------------|---------------|-------------|-------------|
| < 400 cows | 401-500 cows | 501-1000 cows | > 1000 cows | > 2000 cows |
|------------|--------------|---------------|-------------|-------------|

3. Average birth weight of calves?

| | | |
|-----------|------------|---------|
| 30 -35 kg | 36 – 40 kg | > 40 kg |
|-----------|------------|---------|

4. How many heifer calves are reared on the property per annum?

.....

5. At what age is the calf separated from the cow?

| | | | |
|-------------|------------|--------|----------|
| Immediately | 3 – 5 days | 7 days | > 7 days |
|-------------|------------|--------|----------|

6. Specify what is colostrum?

.....

7. Do you measure colostrum quality on your farm before feeding it to a calf?

.....

8. If yes, specify the method you use to measure colostrum quality?

.....

9. How is the colostrum collected?

| | |
|--------------|-----------------|
| Hand milking | Machine milking |
|--------------|-----------------|

10. How is the calf fed colostrum (please tick)

| | | |
|--------------------|-----------------------|----------------------|
| Nursing of the cow | Bucket / teat feeding | Force feeding (Tube) |
|--------------------|-----------------------|----------------------|

11. If fed, how much colostrum is fed per calf? (Please tick)

| | | | | |
|-----|-----------|-----------|-----------|-------|
| 2 L | 2 L – 4 L | 4 L – 6 L | 6 L – 8 L | > 8 l |
|-----|-----------|-----------|-----------|-------|

12. If fed, how soon after birth do you feed colostrum? (Please tick)

| | | | | |
|------------------------|-------------------------|--------------------------|--------------------------|-----------------------|
| < 6 hrs after birth | 6-12 hrs after birth | 12-18 hrs after birth | 18-24 hrs after birth | Longer than 24 hrs |
|------------------------|-------------------------|--------------------------|--------------------------|-----------------------|

13. If fed, do you follow up on the initial colostrum feeding?

| | |
|-----|----|
| Yes | No |
|-----|----|

14. If yes, when do you follow up on your initial colostrum feed?

| | | | |
|----------------------|-----------------------|-----------------------|-------|
| Initial feed + 6 hrs | Initial feed + 12 hrs | Initial feed + 18 hrs | Other |
|----------------------|-----------------------|-----------------------|-------|

15. Do you feed any of these colostrum substitutes? (Please tick)

| | | | |
|------------------|---------------------|------------------|----|
| Frozen colostrum | Fermented colostrum | Pooled colostrum | No |
|------------------|---------------------|------------------|----|

16. How long is your milk feeding period?

| | | |
|---------|--------------|-----------|
| 42 days | 42 – 60 days | > 60 days |
|---------|--------------|-----------|

17. Which liquid feed do you use?

| | | |
|------------|---------------|-------|
| Whole milk | Milk replacer | Other |
|------------|---------------|-------|

18. How much liquid feed do you feed/calf/day?

| | | | |
|-----|-----------|-----------|-------|
| 2 L | 2 L - 4 L | 4 L – 6 L | > 6 L |
|-----|-----------|-----------|-------|

19. How do you house your calves?

| | |
|---------|----------|
| Indoors | Outdoors |
|---------|----------|

20. Tick the major prevalent calf diseases on your farm?

| | | | | |
|---------|------------|-----------------|-------------|-------|
| E. Coli | Salmonella | Eimeria (Cocci) | Pasteurella | Other |
|---------|------------|-----------------|-------------|-------|

21. What is your average mortality rate (%)?

| | | |
|------|-----------|--------|
| < 5% | 5% - 7.5% | > 7.5% |
|------|-----------|--------|

22. Do you test samples (tissue, blood, mucus etc.), to determine cause of death?

| | |
|-----|----|
| Yes | No |
|-----|----|

Thank you for participating in this survey.

APPENDIX C

COLOSTRUM COLLECTION SHEET

Trial site: Blinded
GPS co-ordinates: Blinded
Farm Manager: Blinded
Species: Bovine
Breed: Holstein cows
Samples: Colostrum from the first milking <6 hrs post-partum
Season: Autumn (n=18), Winter (n=42), Spring (n=30)
Cow health: Conditions recorded during last lactation. **Good** (n=0), **Fair** (n=1-2), **Poor** (n=2+)

| Date | Cow no. | Lactation no. | Cow health | Colostrum temp °C at first measure | Colostrometer reading 1 at first measure | Colostrometer reading 2 at 2 nd measure | Colostrometer reading 3, day 21, thawed |
|------|---------|---------------|------------|------------------------------------|--|--|---|
| | | | | | | | |
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