QUANTIFYING ASSOCIATIONS OF COW DRYING-OFF MANAGEMENT PRACTICES WITH MILK YIELD, UDDER HEALTH AND CONCEPTION SUCCESS IN NAKURU PERI-URBAN SMALLHOLDER DAIRY HERDS, KENYA

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EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

Declaration

This research thesis is my original work and has not been presented to any institution for the award of any degree

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Recommendation

This research thesis has been submitted with our approval as the official University supervisors.

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DEDICATION

I dedicate this work to my family, friends and loved ones who immensely contributed to my educational career in one way or the other.

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ABSTRACT

Cow drying-off is a critical transition stage in cow fertility management for dairy farmers that if overlooked or poorly implemented in high milk yielders, could compromise cow health and welfare status, fertility, and milk productivity in the successive lactation cycle. These risks could be higher for cows in peri-urban smallholder dairying where farmers are intensifying production to attain high milk yields, but the effects of their cow drying-off practices on those risks remain a knowledge gap. This study was conducted in Nakuru peri-urban smallholder dairy farms on cows with successive lactations. The objective was to determine mean milk yield at drying-off for the different cow drying-off practices, and during early successive lactation determine milk yield, cases of mastitis and udder leakages, conception successes and days from calving- to- first insemination (D-cfi) for the different drying-off practices that farmers deploy. The study applied a cross-sectional farm survey on 172 farms with 232 cows which had successive lactations. For each cow, historical data was obtained about the two successive lactations and drying-off practices. The differences in means of milk yield at drying-off and during early successive lactation, and D-cfi for the different drying-off practices were estimated with general linear model specification. The odds ratio for cases of mastitis, udder leakages and conception successes for the different drying-off practices were estimated with a binary logistic regression specification. Drying-off practice was most frequently a gradual reduction of milking (47.0 percent) and less frequently salt or teat sealant application (3.9 – 4.7 percent). Milk yield at drying-off averaged 5.3 litres/cow/day while milk yield during early successive lactation averaged 13.4 litres/cow/day, and both showed variation ($p<0.05$) with drying-off practices, breed of cow and dairy intensification. Cases of mastitis, udder leakages and conception success during early successive lactation were each associated ($p<0.05$) with drying-off practices, breed of cow and dairy intensification. The mean number of days from calving-to- first insemination during early successive lactation varied ($p<0.05$) with the drying-off practices that farmers deployed, breed of cow and dairy intensification. The results are relevant to the choice of appropriate cow drying-off management practices that optimize cow udder health, productivity, fertility performance and incomes in peri-urban smallholder dairy herds. Therefore, strengthening drying-off practice will enhance milk yield, cow heath and reproductive performance, productivity and profitability and the overall dairy herd management and sustainability. These finding will provide framework for policymakers, extension delivery service and farmers for the development of dairy sector in peri-urban areas.

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LIST OF ABBREVIATIONS

ADC	Agricultural Development Corporation
AI	Artificial Insemination
AMS	Automatic Milking System
BCS	Body Condition Scores
BDCT	Blankent Dry Cow Therapy
BHB	B- Hydroxybutyrate
DCT	Dry Cow Therapy
DIM	Days in Milk
DLP	Dry Length Period
EMA	European Medication Agency
EU	European Union
IMI	Intermammary Infection
ITS	Internal Teat Sealants
New KCC	New Kenya Cooperative Creameries
PCU	Population Medication Agency
SCC	Somatic Cell Count
TMR	Total Mixed Ration
VWP	Voluntary Waiting Period

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Dairy farming is a fundamental component of agricultural techniques around the world, providing a considerable source of nutrition and income for many communities (Muehlhott & Mcmahon, 2013). One challenging component of dairy farming is cow drying-off, a strategic period during which a nursing cow is briefly halted from milk production to prepare for its next lactation cycle. The methods and timing of drying-off can have a substantial impact on subsequent milk output and cow health and fertility (Rajala & Vilar, 2020). Drying-off triggers several physiological responses with implications on stimulation of the immune system, udder health and welfare status, cow fertility, milk production, and hence profitability in the subsequent lactation (Bhakat & Singh, 2022; Doherty & Mulligan, 2008). At drying-off, the level of milk yield may impact on involution through stimulation of the immune system, udder health and welfare status, cow fertility, and milk production in the subsequent lactation (Bhakat & Singh 2022; Doherty & Mulligan, 2008). These health, welfare, and production concerns will influence the profitability realized. This means that cow drying-off practices should be of managerial concern in the peri-urban smallholder dairy herds where farmers are intensifying production to attain high lactation milk yield. This follows from the fact that high productivity per cow can pose managerial challenges at the moment of drying off the cow at the end of lactation. During dry-off, the shift from a lactating to a no-lactating state, is a sensitive period for dairy cows and signals a stage of heightened sensitivity to intermammary infection (IMI) (Kandeel *et al.*, 2018). With the modern dairy cows increasing milk production capacity (Borawski *et al.*, 2020), drying off has become more difficult.

Smallholder peri-urban dairy production of Nakuru city in Kenya have been described by Migose (2020) as more entrepreneurial and market-orientated but with limited production factors and scarcity of fodder, replacement heifers, and labor. They have variable production strategies, with some being economically positive deviants while some remain typical in their management practices (Migose *et al.*, 2021, 2022). Migose *et al.* (2022) concluded that dairying in peri-urban areas needs interventions that support production intensification and commercial production, with high input use for high output and high productivity per cow. Better market access and higher milk prices in the peri-urban areas encourage good husbandry practices, but whether their good husbandry is reflected in cow drying-off practices is a matter of debate. For these farmers, the level of milk yield that is optimal for drying-off a cow is a challenging decision because milk is a source of continuous stream of income in herds that mostly keep just one cow (Bebe *et al*., 2003).

Evidence shows potential associations of drying-off practices with cow health and welfare status, fertility, milk production, and profitability (O'Hara, 2019). However, the nature of these associations in smallholder peri-urban dairy cows remains a knowledge gap that need closing to inform the design of effective cow drying-off management strategies. Such empirical evidence is valuable to attaining optimal cow health and productivity, reducing the incidence of diseases such as mastitis, and improving milk production and profitability (Doherty & Mulligan, 2008). But smallholder farmers confront a variety of problems, including limited resources, dynamic market conditions, and environmental factors, necessitating a more comprehensive understanding of the relationship between cow drying-off procedures and milk supply (Mccubbin *et al.,* 2022). Therefore, characterizing cow drying-off management strategies in smallholder dairy herds of Nakuru peri-urban needs to be evaluated the associations of cow drying-off practices with the cow health and welfare status, fertility, milk production, and profitability.

Farmers deploy different cow-drying-off practices including changing feed, gradually decreasing milking frequency, or some other drying-off protocols (Bertulat *et al.,* 2015). For farmers to maximize milk yield while guaranteeing cow welfare will require exploring and comprehending the relationships between drying-off procedures and milk production levels (Assani *et al.,* 2023*).* High milk yield at dry-off was found to increase the risk of developing intermammary infection during the dry period and milk leakage. This was because the teat canal's ability to form keratin plugs was impaired (Del Pardo *et al.,* 2020). Furthermore, high milk yield during dry-off was linked to increased udder pressure and stress levels following dry-off, and abrupt discontinuation of milking might induce discomfort and pain (Zobel *et al.,* 2015). Reduced milk production before dry-off and accelerated mammary gland involution are thus favorable to cow health and wellbeing (Cattaneo, 2022). Milk production can be reduced before dry-off by reducing milking frequency or nutritional intake, or by combining both methods (Franchi *et al.,* 2021).

Incomplete milking, which gradually increases early manual cluster detachment, may be a preferred cow drying-off practice for lowering milk production in dairy cows (Meyer *et al.,* 2023). Incomplete milking for 5 days in milking (DIM) by reducing milk production can reduce metabolic stress in cows. In a study of the consequences of incomplete milking 10 days before dry-off, Martin *et al*. (2020) and Bach *et al*. (2022) created a software module that automatically withdrew the milking cluster at a predetermined target setting before reaching the conventional cluster take-off level. The step-down program lowered daily udder emptying. Before milking was stopped, milk production was cut by 35% on average. From this study, it has been proposed that the stimulation of mammary gland involution is caused by a detectable increase in the acute-phase protein haptoglobin in foremilk samples (Martin *et al.,* 2020). Although the concept of partial milking is still under development, it could be applicable for drying off by automatically managing partial milking.

There are numerous drying-off procedures in general, including those that are done abruptly or gradually. A quick end to milking is referred to as abrupt dry-off, whereas gradual drying-off procedures try to diminish milk output before dry-off. Gradual dry-off is accomplished by reducing milking frequency or nutrient intake, or by combining both procedures (France *et al.,* 2022). Drying-off is also treated with antibiotic dry cow therapy (DCT), teat sealants, and adjustments in cow housing. Furthermore, pharmaceuticals such as dopamine agonists that inhibit prolactin release (Watanabe *et al.*, 2023), chitosan hydrogels (Lacasse *et al.,* 2019), casein hydrolysates (Kholer *et al.*, 2017), and acidogenic mineral boluses that induce transient metabolic acidogenesis (Vilar *et al.*, 2023) can aid in drying-off. These chemicals, however, are not widely available commercially. Despite research attempts to create alternative drying-off procedures and improve those that are currently in use (Bach *et al.,* 2022), knowledge regarding the practices that are currently used on dairy farms is limited. Furthermore, there is a paucity of knowledge about farmers' willingness to embrace novel drying-off procedures. Farmers' adoption of management strategies is influenced by their unique circumstances, such as farm characteristics, as well as their perceptions of the effectiveness and feasibility of recommended practices (Ritter *et al.*, 2017). As a result, it becomes appropriate to inform farmers about breakthroughs in drying-off procedures early and solicit their feedback on these approaches.

1.2 Statement of the Problem

Peri-urban smallholder dairy farmers are intensifying production to increase milk yields. However, high milk yielding cows require high level husbandry in drying-off practices that if overlooked or poorly implemented could compromise their health and welfare status, fertility, milk production, and subsequently adversely impact profitability in the next lactation cycle. Farmers deploy variable husbandry practices, implying heterogeneity in cow drying-off management practices, but their associated risk effects are a knowledge gap area in extension advisory to farmers about which drying-off practices optimizes cow health and productivity.

1.3 General Objective

This study contributes to increasing milk productivity (SDG 2: ending hunger) and increasing incomes (SDG 2: alleviate poverty) for smallholder farmers through determining drying-off management practices that enhance cow health and welfare status, fertility, milk production, and profitability in successive lactation cycles.

1.3.1 Specific Objective

i. To assess the mean milk yield at cow drying-off for the different cow drying-off practices that farmers deploy in Nakuru Peri-urban area.
ii. To assess the mean milk yield in the successive early lactation cycle for the different cow drying-off practices that farmers deploy in Nakuru peri-urban area.
iii. To determine association of cases of mastitis and udder leakages in the successive early lactation cycle with different cow drying-off practices that farmers deploy in Nakuru peri-urban area.
iv. To determine the mean number of days from calving- to- first insemination and cases of conception success in the successive early lactation cycle associated with the different cow drying-off practices that farmers deploy in Nakuru peri-urban area.

1.3.2 Research Questions

i. Is the mean milk yield at drying-off significantly different for the different cow drying-off practices that farmers deploy in Nakuru peri-urban area?
ii. Is the mean milk yield in the successive early lactation cycle significantly different for the different cow drying-off practices that farmers deploy in Nakuru-peri urban area?
iii. Are the cases of mastitis and udder leakages in the successive early lactation cycle significantly different for the different cow drying-off practices that farmers deploy in Nakuru peri-urban area?
iv. Is the mean number of days from calving- to- first insemination and cases of conception success in the successive early lactation cycle significantly different for the different cow drying-off practices that farmers deploy in Nakuru peri-urban area?

1.4 Justification

Effective cow drying-off management practices are essential for attaining good cow health and welfare status, fertility, and milk production in the next lactation cycle. This is in line with SDGs one, two, and three, which address no poverty, eradicating hunger, and good health and well-being. This translates to the profitability of the dairy enterprise but is a great challenge in the peri-urban smallholder dairy farms where farmers lack evidence of the consequences of their drying-off management practices. Therefore, generating empirical evidence on cow dry-off management strategies in smallholder dairy herds of Nakuru peri-urban would inform the development of appropriate and effective dry-off management practices to enhance udder health and welfare, fertility, and productivity needed to sustain a profitable dairy enterprise.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cow drying-off Management Practices and Importance

Drying-off activities are the procedures and techniques used in the dairy business to temporarily stop milking cows, usually in preparation for the dry time of the lactation cycle (Nitz *et al.,* 2021). The drying-off methods are employed to allow the animal's udder to relax and rebuild between lactations while reducing the danger of illnesses like mastitis, which can be frequent in dairy animals (Larsen *et al.,* 2021). A dairy cow's dry period should be regarded as a crucial stage in her lactation cycle. Cows are at a significant risk of having mastitis during the first three weeks after drying off because they are going through physiological changes and are more vulnerable to bacteria from the environment since the keratin plug is not fully established in all quarters during this time. Adequate diet and illness prevention for the cow at this time will promote optimal health, milk production, and reproductive performance during the lactation following calving. As a result, the economic importance of dry cow nutrition and management cannot be overstated (Sammad *et al.,* 2020). Farmers around the world use a variety of drying-off procedures, including gradual reduction in milking frequency, cessation of milking, teat washing and sanitization, udder health monitoring, teat sealing, and nutritional correction (Cattaneo *et al.,* 2023).

The purpose of drying off a cow is to stop milk secretion abruptly and seal the teat canal as rapidly as possible. Cows should not be milked intermittently near the end of lactation since this prevents the teat canal from sealing and creates a continuous stimulus for milk production, increasing the risk of mastitis in the cow. The veterinarian-recommended dry cow therapy should be delivered following the cow's final milking (Nyman &Waller, 2021). Teat sealant can also be used to keep bacteria from getting into the teat cistern and causing new infections. Finally, a good teat dip should be used to cover the whole surface of the teats (Bayoumi & Kamal, 2015).

Dry cow therapy can clear up to 98% of existing infections and help prevent new infections, making it one of the most cost-effective techniques of mastitis prevention (Gravel & Malouin, 2019). Sub-clinical mastitis avoidance is especially crucial at this time since it can precede clinical cases and, depending on the bacteria involved, can infect additional animals. Every quarter following the cow's final milking, a long-acting intra-mammary antibiotic should be given **(**Derakhshani *et al.,* 2018).

Nutrition during the dry period is critical for sustaining a body condition score of 3.0 to 3.25. Separate diets should be developed for distant and close-up dry cows. Diets of distant cows should be low in calories and high in fiber (Bridges, 2018). Close-up dry cow diets should contain more metabolizable protein and energy than far-away dry cow diets, but they should also contain controlled levels of both energy and fiber to guarantee appropriate feed intake after calving (Mann *et al.,* 2015). Protein depletion during the dry period might have a significant impact on the cow's health, milk production, and reproductive performance during the following lactation (Sehested *et al*., 2019). Close-up cow diets can also include low-potassium forages like corn silage and grain products to assist in reducing milk fever after calving. If a herd is too small to manage close-up and far-away dry cows separately, dry cows can be managed as a single group with a shortened dry period and a negative DCAD diet (Lopera *et al.*, 2018).

Dry periods are typically 60 days long and include both a far-off and a close-up time. Three weeks before the projected calving date, the close-up period begins (Roche *et al.*, 2017). According to research, if a cow is not given a dry time, she will produce 25 to 30% less milk following lactation (Santshi *et al*., 2011). Some growers, however, have recently begun to use shorter dry times of 40 to 42 days. These shorter dry periods involve only one group and are combined with a nutrition program based on a negative dietary cation-anion differential (DCAD) (Martinez *et al.,* 2018). Some believe that the benefits of utilizing this approach include having cows produce milk for an additional 18 to 20 days and requiring less effort and stress because cows only need to be housed in one group rather than two (Rodenburg, 2019). According to research, there is no difference in milk yield between a 30-day dry period and a 60-day dry period for multiparous cows. A 30-day dry intervals in primiparous (first-calf) cows, on the other hand, have been shown to diminish milk supply (Zezeslci *et al.,* 2015).

Heat stress should also be avoided by providing adequate cooling through the use of shade, fans, and sprinklers. Because heat stress limits the amount of mammary tissue that may be produced, a cow who is heat-stressed during her dry phase will have a lower capacity for producing milk in her subsequent lactation (Dahl & Tao, 2013). Dry cows that are cooled throughout the summer months have been demonstrated in studies to produce 4.5to 5.4kilograms more milk per day during lactation than cows that do not receive additional heat abatement (Toledo & Vries, 2022).

Reducing close-up cows' social, environmental, and metabolic stress: Stress can impair feed intake, immunological function, and overall health and productivity in cows during the calving season. Social stress can be reduced by having as few pen moves or regroupings of cows as feasible to avoid disrupting the cows' social hierarchy. It is advisable to add numerous cows to a group at once rather than adding cows separately (Overton *et al.,* 2024). To ensure optimum dry matter intake and prevent competition for feed, provide 36 inches of feed bunk space per cow to lessen social and metabolic stress. To guarantee enough lying time, a minimum of one free stall or 100 to 125 square feet per cow should be provided (Shepley *et al.,* 2020).

Drying off cows quickly, using a teat sealant, and delivering veterinarian-recommended dry cow therapy will help protect cows from infections throughout the dry phase and avoid mastitis in the following lactation. Meeting cow nutrition needs, depending on the stage of the dry period and the length of the dry period, can help prevent transition cow problems and promote optimal milk production in the following lactation. Adequate heat abatement will prevent the harmful consequences of heat stress, and reducing regrouping and pen changes will reduce dry cow social stress. These steps will assist dry cows in having greater health, milk output, and reproductive performance in their next lactation (Grewal *et al*., 2018).

2.2 Influence of Daily Milk yield on Drying-off Practices

During dry-off, the shift from a lactating to a no-lactating state is a sensitive period for dairy cows and signals a stage of heightened sensitivity to intermammary infection (Rowe *et al.,* 2020). With the modern dairy cow's improved milk production capacity (Barkema *et al.,* 2015), drying off has become more difficult. High milk yield at dry-off was found to increase the risk of developing milk leakage (Bertulat *et al.,* 2013; De Prado-Taranilla *et al.,* 2020; Gott *et al.,* 2016) and intermammary infection (IMI) during the dry period (Rowe *et al.,* 2021) because the keratin plug formation in the teat canal was impaired (Notcovich, 2021).

Furthermore, high milk yield during dry-off was linked to increased udder pressure and stress levels following dry-off, and abrupt discontinuation of milking might induce discomfort and pain (Bertulat *et al.,* 2013; Silanikove *et al.,* 2013; Zobel *et al.,* 2015). Reduced milk production before dry-off and accelerated mammary gland involution are thus favorable to cow health and well-being Milk production can be reduced before dry-off by reducing milking frequency or nutritional intake, or by combining both methods (Larsen *et al.,* 2021; Tucker *et al.,* 2009). Incomplete milking, which gradually increases early manual cluster detachment, may be an alternate technique for lowering milk production in dairy cows (Albaaj *et al.,* 2018; Kuehnl *et al.,* 2019; Penry *et al.,* 2017). By decreasing milk production during the first 5 DIM, incomplete milking reduced metabolic stress in cows (Meyer *et al.,* 2023; Morin *et al.,* 2018). Investigated the consequences of incomplete milking 10 days before dry-off. For this reason, they created a software module that automatically withdrew the milking cluster at a predetermined target setting before reaching the conventional cluster take-off level (Martin *et al.,* 2020). The step-down program lowered daily udder emptying. Before milking was stopped, milk production was cut by 35% on average. It has been proposed that the stimulation of mammary gland involution is caused by a detectable increase in the acute-phase protein haptoglobin in foremilk samples (Martin *et al.,* 2020). Although the concept of partial milking is still under development, it could help with drying off by automatically managing partial milking.

There are numerous drying-off procedures in general, including those that are done abruptly or gradually. A quick end to milking is referred to as abrupt dry-off, whereas gradual drying-off procedures try to diminish milk output before dry-off. Gradual dry-off is accomplished by reducing milking frequency or nutrient intake or combining both procedures. Drying-off is also treated with antibiotic dry cow therapy (DCT), teat sealants, and adjustments in cow housing. Furthermore, medications such as dopamine agonists that suppress prolactin production (Lacasse *et al.,* 2019), Casein hydrolysates (Ponchon *et al.,* 2014), chitosan hydrogels (Lanctôt *et al.,* 2017), and acidogenic mineral boluses that promote transitory metabolic acidogenesis (Maynou *et al.,* 2018) can aid in drying off. However, these compounds are not commonly available commercially.

Antibiotic stewardship and animal welfare are two current public-interest issues. Although antibiotic therapy is crucial in maintaining sick animals' health and well-being, less and more careful antibiotic administration is required because antimicrobial resistance has become a global public health concern (Dhingra *at al.,* 2020). As a result, since the law changed in 2016, antibiotics may no longer be administered in Switzerland for preventive use (Manjush *et al.,* 2016). Simultaneously, there is a trend toward a decrease in farm numbers and an increase in farm size (Berckmans *et al.,* 2014).

Consumers, on the other hand, prefer small-scale farms because they feel natural housing conditions are critical for animal wellbeing and that such conditions can only be found on small-scale farms (Cardoso *et al.,* 2016; Krystallis *et al.,* 2009; Spooner *et al.,* 2014). As a result of the expansion of the dairy sector, animal welfare has become an increasingly relevant problem for consumers (Barkema *et al.,* 2015; Spooner *et al.,* 2014). Despite research attempts to create alternative drying-off procedures and improve those that are currently in use (Dancy *et al.,* 2019; Larsen *et al.,* 2021; Martin *et al.,* 2020). Knowledge regarding the practices that are currently used on dairy farms is limited. Furthermore, there is a paucity of knowledge about farmers' willingness to embrace novel drying-off procedures. Farmers' adoption of management strategies is influenced by their unique circumstances, such as farm characteristics, as well as their perceptions of the effectiveness and feasibility of recommended practices (Ritter *et al.,* 2017).

2.3 Influence of Daily Milk Yield before Drying-Off on Udder Health and Animal Welfare in Subsequent Lactation

Dairy farming in developed countries has undergone significant structural changes in recent decades, with the number of farms dropping and herd sizes growing. Milk output before dry-off affects not just susceptibility to IMI (Lacasse &Ollier, 2015), but also the likelihood of increased pain and suffering during dry-off (Ametaj & Egyedy, 2022). Cows having a high milk supply at dry-off may have less laying time after drying off due to udder discomfort (Chapinal *et al.,* 2014), and this may be especially true of cows that are dried off suddenly rather than gradually (Rajala-Schultz *et al.,* 2018). Reducing milk supply before dry-off may thus be advantageous to cow health. Gott *et al.* (2016) observed that reducing milking frequency to 1 time/day from 2 times/day lowered milk supply by up to 33% during the final week of lactation. No harmful consequences of lowering milking from two times per day to one time per day have been documented in any study to date (Tucker *et al.,* 2009) on cow health and behavior, implying that reducing milk output before dry-off by reducing milking frequency is more advantageous than harmful. Another way to lower milk yield before dry-off is to restrict dietary nutrient intake, ideally without generating hunger in cows, which could hurt the well-being of cows (Zobel *et al.,* 2015)

Milk production per cow has increased as a result of genetic selection and advances in nutrition and dairy cow management (Barkema *et al.,* 2015). High-yielding dairy cows struggle to shift to a non-lactating state after lactation. This non-lactating interval, however, is critical for optimizing milk production and udder health in the succeeding lactation. The start of the dry period is a high-risk period for new intermammary infections (IMI) in cows (Kabraetal *et al*., 2021). Antibiotic dry cow therapy (DCT) has long been used to control udder health during dry-off and the dry period, however new worries regarding antimicrobial resistance have grown (Loo & Mansor, 2019). Animal welfare has also grown in popularity among consumers (Haseth & Sodring, 2020).

One current difficulty for the dairy business is balancing management methods in increasingly intense production systems with animal health, welfare, and production sustainability. This implies optimizing drying-off procedures that take into account all of these factors of dairy production for dry cow management. Various drying-off procedures used to prepare cows for the dry (non-lactating) period varied substantially between nations, herds, and even cows within herds. Drying-off practices include various milk cessation methods (reduced frequency of milking and changes in feeding), administration of DCT and internal teat sealants, and housing changes. The methods used are either abrupt or gradual dry-off. In the former, all drying-off practices occur in 1 day, whereas in the latter, they may extend from a few days to several weeks before the final milking. Milking methods range from stopping milking on a specific day to gradually reducing milking frequency over several days or weeks, with or without calorie and nutrient constraints. Pharmaceutical therapies have lately been investigated to aid in this process (Boutinaud *et al.,* 2016; Maynou *et al.*, 2018; Shamay *et al.,* 2003). The impact of dry-period length on milk production in the following lactation has been extensively studied (Bachman & Schairer, 2003; Pezeshki *et al.,* 2010; Van Knegsel *et al.,* 2013), as has the impact of antibiotic DCT on dairy cow udder health (Cameron *et al.,* 2014). However, published studies on the actual procedures used to stop cow milk production in preparation for the dry period are surprisingly sparse. There is no uniform drying-off technique in place to improve udder health, cow welfare, and productivity in the subsequent lactation.

2.3.1 Udder Health during the Dry Period

Two important times of the dry season when udder health is at stake approximately 60% of all early lactation mastitis cases have a dry period origin (Pantoja & Ruegg, 2009). As a result, to prevent new infections from emerging before calving and to cure any existing infections, dairy farmers must be at risk the first week after drying off and the week before calving (Cameron *et al.,* 2014). The udder's natural defense mechanism, a keratin plug in the teat canal, is generated during the first critical stage, and this plug gradually dissolves in preparation for lactation during the second critical stage, before calving. During the dry period, the keratin plug inhibits bacteria from accessing the teat canal (Lacasse, & Ollier, 2015). The udder is very susceptible to new infections at the beginning and end of the dry period. Furthermore, some cows do not form a keratin plug in the teat canal during the entire dry period (Zemanova *al.,* 2022).

Good milk output management at the point of drying off is critical because a high milk yield increases the chance of getting a new intra-mammary infection by 100% after drying off

(Nitz *et al.,* 2021). A significant volume of leftover milk in the udder stimulates white blood cells to focus on absorbing milk fat cellular debris and become less active in preventing germs from accessing the udder (Campione *et al.,* 2020). Furthermore, cows with a high milk volume during drying off have a weaker keratin plug than other cows due to delayed keratin plug production in the teat canal (Rajala & Vilar, 2020). The transition period, which is typically described as the three weeks preceding and three weeks following calving, is vital to the health, output, and profitability of dairy cows. (Cardoso *et al.,* 2020) The fetus' nutritional requirements are at their peak three weeks before calving, although dry matter intake (DMI) drops by 10% - 30% (Gionbelli *et al.,* 2016). Until the first 2 to 3 months of lactation, the energy requirements for milk yield surpass the calorie intake. (Mäntysaari *et al.,* 2019). Because of these factors, transition cows have a negative energy balance (EB), which occurs when a cow's energy requirements cannot be supplied by the energy she consumes. The mobilization of bodily reserves to compensate for this energy deficit is related with altered metabolic status, a higher frequency of metabolic disorders such as ketosis, displaced abomasum, mastitis, and lower fertility under negative EB. (Deniz & Metin, 2020).

Many studies have found that a dry period (DP) of 42 to 60 days is ideal (Grewal *et al.,* 2018). Lowering the DP is linked to lower milk supply in later lactation (Van *et al.,* 2017). Some researchers examined the impact of reducing or eliminating the DP on dairy cow lactation performance, metabolic state, health, and reproduction (Hoeij *et al.,* 2018). High-yielding cows with DP shortening or omission must produce less milk the following lactation, but may have less metabolic burden and negative EB in early lactation (Bruckmaier & Gross, 2015). However, there have been few investigations on the effect of removing the DP when applied to transition cows under heat stress. Heat stress is a significant element that has a negative impact on milk yield, reproduction, health, and welfare, resulting in economic constraints for dairy farms. (Becker *et al.,* 2020). Lactating dairy cows produce much more metabolic heat and extra heat from radiant radiation, and they have a harder time dispersing heat stress than non-lactating cows (Idris *et al.,* 2021). Heat stress during the DP persists throughout the postpartum period, resulting in a decrease in milk production and a deleterious impact on hepatic metabolism. (Gessner *et al.,* 2015). It is uncertain if eliminating the DP mitigates the deleterious effects of pre- and postpartum heat stress on performance. The current study sought to compare the effects of typical DP (60-d DP) versus no DP (0-d DP) on EB, milk production, milk composition, and metabolic state in dairy cows subjected to heat stress from 8 weeks before calving to 10 weeks after calving.

In dairy farming, cow udder health management is critical to ensure both animal welfare and operation sustainability (Ariton & Valeanu, 2022). Proper drying-off methods are an important part of udder health management (Bertulat & Heuwieser, 2015). The dry interval, which occurs between lactation cycles, allows cows to rest and regenerate their bodies before the following lactation cycle begins. However, how drying-off is carried out can have a considerable impact on cow udder health and welfare, especially in subsequent lactation cycles (Arnott *et al.,* 2017).

Drying-off procedures in dairy farming are the management strategies used to stop milk production in nursing cows at the end of their lactation cycle. The dry season allows cows to recover and prepare for the next lactation cycle. Proper drying-off methods are critical for preserving udder health and dairy cow welfare (Bertulat *et al.,* 2015).

Nakuru, a location in Kenya's Rift Valley, is home to several smallholder dairy farms. These farms serve an important role in supplying milk to local markets and supporting many rural households. However, constraints such as insufficient finances, inadequate infrastructure, and a lack of access to veterinary services frequently have an impact on dairy cow management and welfare in peri-urban settings (Moje *et al.*, 2023).

The purpose of this study is to investigate the impact of drying-off procedures on cow udder health and welfare status of peri-urban smallholder dairy farms in Nakuru. These farms, located in the heart of Kenya's dairy-producing region, are an important part of the local dairy sector, providing milk to both rural and urban markets (Kamundi, 2014). Despite their importance, smallholder dairy farms frequently confront various obstacles, such as limited resources, inadequate infrastructure, and a lack of access to veterinary services (Abebaw & Guadu, 2016).

Understanding the influence of drying-off procedures on cow udder health and well-being is critical in addressing the unique issues that smallholder dairy farmers confront (Hansen & Jensen, 2023). Drying-off techniques and their subsequent impacts on udder health are influenced by a variety of factors, including farmer education and awareness, availability of veterinary services, farm management practices, and socioeconomic restrictions.

Udder health is crucial for dairy cows' welfare and productivity (Ariton & Neculai, 2022). Mastitis, an inflammatory illness of the udder, is one of the most common and expensive diseases affecting dairy cows globally (Ibrahim, 2017). Poor drying-off techniques can contribute to the development of mastitis and other udder health disorders, jeopardizing cow welfare and production in future lactation cycles (Kibebew, 2017).

Regardless of the DCT used, high milk supply at dry-off (i.e., last milking) leads to greater milk buildup in the udder in the following days, which produces increased intermammary pressure and increases the likelihood of milk leakage (Bertocchi *et al.,* 2020). However, a short or missing dry season can have an impact on udder health. Shortening the dry time did not appear to have any negative consequences on udder health, including the risk of mastitis (Hertl *et al.,* 2014). Cows handled preferentially during dry-off may benefit from a prolonged dry spell. In reality, the dry period is a crucial phase for treating IMI, even subclinical (i.e., low SCC but the presence of some pathogen strains), because, in addition to the antibiotic impact, many bacteria are physiologically cleared during the mid-dry period. In those days, slow dry-off was employed to lower the incidence of mastitis induced by excessive intermammary pressure (Zigo *et al.,* 2021). However, when antibiotic therapy spread, dry-off was eventually replaced with sudden dry-off (Cattaneo *et al.,* 2022).

By analyzing these processes, this study hopes to provide insights into how drying-off procedures might be optimized to improve cow udder health and welfare in subsequent lactation cycles. Finally, the study's findings can help to shape targeted interventions and best practices for Nakuru peri-urban smallholder farms, thereby improving animal welfare, farm production, and the overall sustainability of the region's dairy sector.

2.3.2 Dry off Treatment

During the first several weeks of drying out, intra-mammary antibiotic treatment will eradicate current infections and prevent new infections. However, due to antibiotic coverage limitations, this treatment will not prevent new infections later in the dry period (Kabera *et al.,* 2021). According to worldwide and Lely research, employing an internal teat sealant in conjunction with antibiotics minimizes the incidence of new infections even further (Levin, 2001). The internal teat sealant mimics the natural keratin plug and prevents bacteria from entering the teat canal (Freu *et al.,* 2020). The use of an internal teat sealant alone is possible in low somatic cell count (SCC) cows, but extra hygienic care must be taken when administering the teat sealant.

The right dry-off treatment should be discussed with the herd veterinarian and documented in an SOP manual (Nydam & Potter, 2022). The duration of the dry season, the presence of certain mastitis bacteria, treatment success, farm-specific situations, and so on all influence the therapy (Doehring & Sundrum, 2019). Dry-off therapy and management can be objectively evaluated and changed if the SCC level of cows is monitored before the commencement of the dry period and again after calving (Rajala *et al.*, 2011).

2.3.3 Reducing the Risk of Infection Early in the Dry Period

The amount of milk the cows are still providing during the dry time is one of the most important elements in assessing dry-off success (Chapinal *et al.*, 2013). The goal is to reduce milk yield to less than 33 pounds. This can be accomplished by reducing concentrates promptly as well as lowering the calorie and protein composition of the feed (i.e. providing more fibrous roughage such as hay or silage) (Muller, 2018). For additional information about the T4C management program's settings.

Milking should be halted immediately. It is not recommended to continue milking cows fewer than twice a day before dry-off, as this raises the risk of new infections and delays the creation of the keratin plug once milking has ceased (Hale *et al.*, 2003). After the last milking, the dry-off therapy should be used in a safe and clean setting. Before delivering the treatment, the teat ends should be cleansed, and the teats should be dipped (Rasmussen, 2011). Reducing the risk of infection during the entire dry period Proper cleanliness and a good barn climate prevent bacteria from growing/persisting in bedding material and potentially contaminating the udder when lying down (Wolfe *et al.*, 2010). A well-balanced diet of calories, protein, minerals, and vitamins is essential for maintaining the cow's immune system and maintaining an optimal Body Condition Score (3 - 3.5) (Zin *et al.*, 2020) Minimize stress: stress reduces the cow's immune Increase cow comfort (comfortable bedding, exercise area): this will result in better overall health and may aid in the reduction of udder oedema (Grandin & Okkema, 2021).

Reduced infection risk during calving Udder oedema impairs blood flow and immunological function, increasing the risk of mastitis (Fehr *et al.*, 2018). Udder oedema is also caused by consuming too much Na+ and K+ during the dry phase, which causes fluid retention (Bachmann & Ploeg, 2002). A higher intake of these ions raises the risk of hypocalcemia (Vuralli, 2019). Na+ and K+ are particularly abundant in grassland products. Cows that lose milk before calving should be milked and their colostrum should be frozen: milking will flush out any germs in the teat canal. Furthermore, milk removes free fatty acids from the blood, lowering the risk of fatty liver syndrome and ketosis (Watanabe *et al*., 2020). It is critical to ensure that animal health issues are dealt with correctly and that the labour involved in treatment is efficient, especially as herd sizes grow greater (Gotz & Petrick, 2019). Farms equipped with an automatic milking system have an additional tool at their disposal to boost the effectiveness of the treatment and, as a result, reduce the work required by the farmer to get the best results (Hilkens *et al*., 2015).

2.4 Influence of Milk Yield before Drying-Off on Cow Fertility

The effects of several Voluntary wait periods (VWPs) on reproductive performance are equivocal. In some research, cows with a lengthier VWP had greater conception rates at first AI and fewer days open following the conclusion of the VWP; however, other studies found no effect of VWP on these variables (Figure 1). A study of 51,528 first inseminations indicated that the conception rate increased with weeks in milk and was 6% lower when cows were inseminated before peak milk supply (Inchaisri *et al.*, 2011). This could explain the findings of Niozas *et al.* (2019) who found that cows with a VWP of 40 d (37%) had a lower conception rate at first AI than cows with a VWP of 120 (49%) or 180 d (50%).

Cows with an extended VWP may have better reproductive performance because they have more time to recover from calving, more time to recover from NEB, and a reduced milk yield at the start of the breeding phase. Extending the VWP from 60 to 88 days resulted in a lower percentage of polymorph nuclear cells in uterine samples and a tendency for a lower concentration of haptoglobin in plasma during the breeding period, indicating that cows with the extended VWP had a better uterine health status and lower inflammatory status (Stangaferro *et al.*, 2018). Furthermore, in our recent study (Ma *et al.*, 2020), cows with a prolonged VWP of 125 or 200 d had a higher percentage of normal ovarian cycles (18-24 d in length) during the 100 days preceding the VWP's completion. However, not all research mentions the effects of prolonging the VWP on body condition, energy status, or milk yield near the conclusion of the VWP to comprehend the effect, or lack thereof, of a longer VWP on fertility.

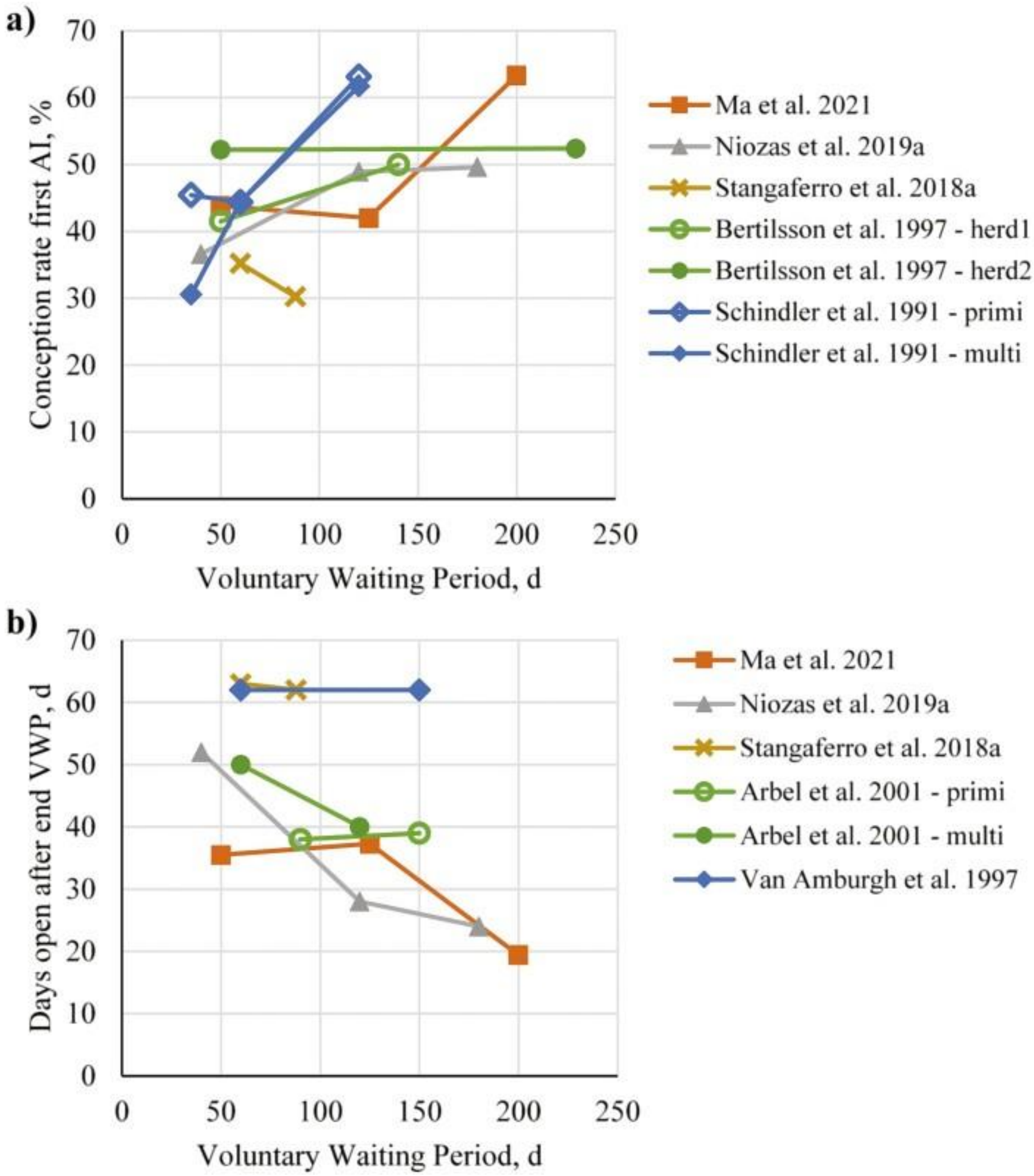

Figure 1: First AI conception rate (a) and days open (b) following the conclusion of the voluntary waiting period (VWP) for pregnant cows in each experiment.

Source; Pezeshki *et al.* (2010)

Key: Voluntary Waiting Period, Day

Nonetheless, studies varied in how long the VWP is extended, in addition to the variances in reproduction methodology noted above. When the VWP is extended to a small extent, the impacts on milk yield, body condition, ovarian cyclist, or uterine health state at the time of insemination may be restricted. Cow fertility is critical for dairy farmers who want to preserve herd productivity and profitability. Drying-off, or the stoppage of milk production before calving, has a significant impact on dairy cow reproductive performance in subsequent lactations. Management decisions taken during this phase can have a considerable impact on the cow's reproductive health and lactation outcomes (Crowe *et al.,* 2018). It is well proven that dry cow management and the dry season are crucial for animal health (Laven *et al.,* 2019), milk production (Krattley *et al.,* 2021), and fertility (Fujiwara *et al.*, 2018) of dairy cows in the following and subsequent lactations.

In recent years, there has been an increased understanding of the complex link between drying-off methods and cow fertility. The duration of the dry phase, nutritional management throughout the dry period, and the use of hormonal therapies have all been identified as possible predictors of reproductive success following lactation (Michael *et al.,* 2019).

Understanding how drying-off methods affect cow fertility necessitates a thorough assessment of numerous physiological, dietary, and management factors (Van *et al.,* 2021). Proper dry period management can assist dairy cows overcome metabolic problems, improve body condition, and increase reproductive efficiency (Caixeta & Omontese, 2021). In contrast, poor drying-off methods may raise the incidence of reproductive diseases, extend calving intervals, and diminish overall herd output (Sharun *et al.,* 2021).

Dry Period length also influences dairy cattle reproductive performance (RP). However, genetics, management, and feeding techniques are the key influences on cattle RP (Mahnani *et al.,* 2021). Dairy operations can develop alternative management measures to increase dairy cattle reproductive efficiency. The elimination or reduction of extended dry periods may improve RP and hence the organism's energy balance (Metin *et al.,* 2020). Following parturition, dairy cows establish a negative energy balance and experience body condition losses that support milk synthesis.

The purpose of this study is to determine the impact of drying-off procedures on cow fertility performance across successive lactations. We hope to understand how drying-off procedures affect reproductive results in dairy cows by analyzing parameters such as dry period length, nutritional modifications, and hormonal interventions. Finally, the outcomes of this study project can help dairy farmers and industry stakeholders optimize management practices and increase the fertility performance of dairy herds.

2.5 Influence of Drying-Off Practices on Milk Productivity in Subsequent Lactation

Many studies have found that a dry period (DP) of 42 to 60 days is appropriate (Lim *et al.,* 2023). Lowering the DP is associated with reduced milk production later in lactation (Boustan *et al.,* 2021). Some studies have looked at the impact of reducing or eliminating the DP on lactation performance, metabolic state, health, and fertility in dairy cows (Ma *et al.,* 2020). High-yielding cows with DP shortening or omission must give less milk the following lactation but may have less metabolic burden and negative EB in early lactation (de Brujin *et al.*, 2023). However, there have been few investigations on the effect of removing the DP when applied to transition cows under heat stress. Heat stress is a primary factor that reduces milk yield, reproduction, health, and welfare, resulting in financial constraints for dairy farms (Brito *et al.,* 2021). Lactating dairy cows have much more metabolic heat and extra heat from radiant radiation, as well as more difficulty dispersing heat stress (Charlie *et al.,* 2020). Heat stress during the DP persists throughout the postpartum phase, resulting in decreased milk production and a detrimental impact on hepatic metabolism (Muriu, 2023). It is uncertain if eliminating the DP mitigates the deleterious effects of pre-and postpartum heat stress on performance. The current study sought to compare the effects of typical DP (60-d DP) versus no DP (0-d DP) on EB, milk production, milk composition, and metabolic state in dairy cows subjected to heat stress from 8 weeks before calving to 10 weeks after calving.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The research was carried out in four wards (Lanet, Njoro, Kabatini, and Lare) around the peri-urban areas of Nakuru City, as illustrated in Figure 3. Lanet and Kabatini are within the Bahati sub-county which covers an area of 375.4 km^2 while Njoro and Lare are wards within the Njoro sub-county with an area covering 713 km^2. Bahati sub-county lies between longitudes 35°28' and 35° east and Latitude 0°13' and 10°10' South at an altitude of about 1912 meters above sea level. This sub county covers an area of 375.4 km^2 with an estimated population of 141,352 (KNBS, 2019). Njoro sub-county lies between latitude 00° 19' 00" S and longitude 36° 06' 00" E in Low Highlands (LH3) and Upper midlands (UM4) ecological zones with an altitude of 2168m to 2800 m above sea level. The temperatures range from a minimum average of 10˚C during the cold months of July to August and 20˚C during the hot months (January to March). Rainfall is bimodal, with long rains (March to April) and short rains (October to December).

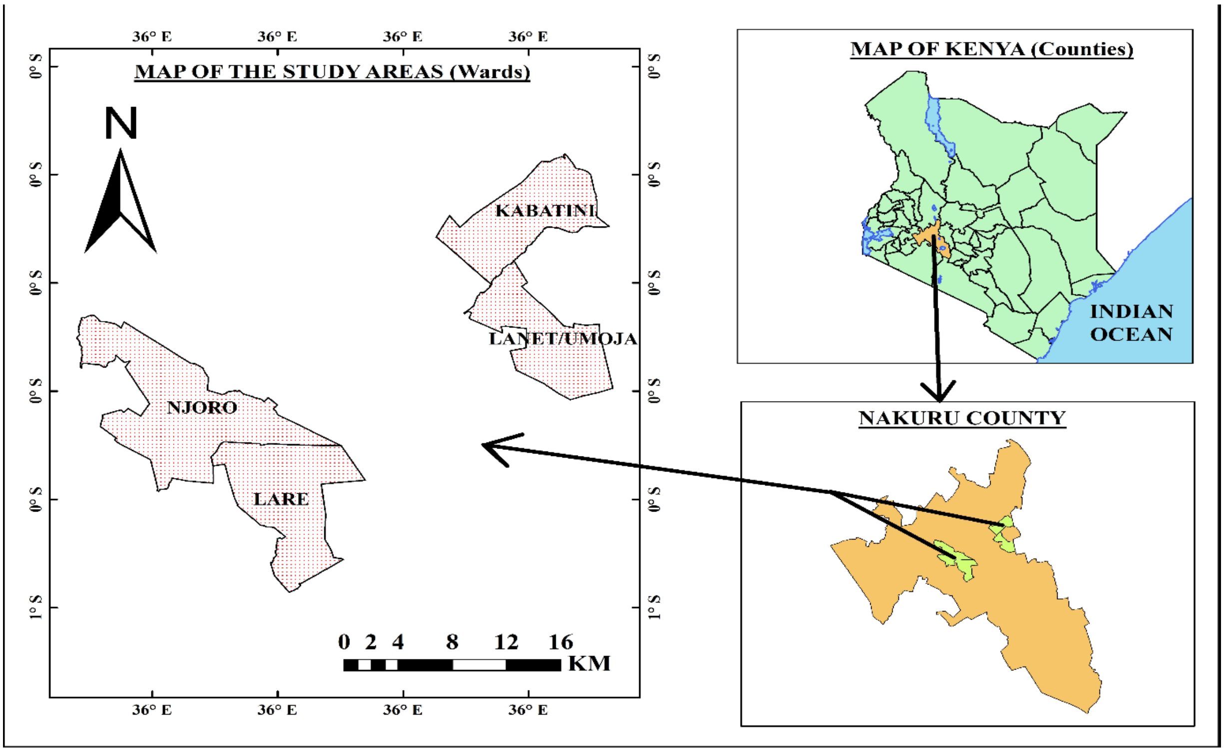

Figure 2: Map of the peri-urban areas of Nakuru County, Kenya

Source: Self QGIS

In the study area, dairy cattle may be managed under free-grazing, semi-zero-grazing or zero-grazing, which in that order represent an increasing level of dairy intensification management. Milk may be marketed through formal or informal market outlets. Mastitis infections are prevalent and cow drying-off practices are variable, with use or without use of antimicrobial drugs (Kashongwe *et al.,* 2017).

3.2 Study Design and Sampling Process

The study was a cross-sectional observational survey in which farms were selected randomly, and the sample unit was a cow with successive lactations. On each farm, all the individual cows with successive lactations present were examined. The number of cows with successive lactations required was estimated using the Nomogram of Altman as described by Petrie and Watson (2013).

The number of cows with successive lactations (p_1) was based on reported estimate of 34 percent in the target sample cattle population (Bebe *et al.,* 2003; Wairimu *et al.,* 2021). With this observed prevalence of 34 percent, the sample size required was estimated to have a 95 percent chance of detecting a 5 percent difference at 5 percent level of significance by computing the mean prevalence (P) of cows from an equation specified as:

Standardized difference: $= \frac{P1-P2}{\sqrt{\bar{P}}(1-\bar{P})}$ (1)

where, $\bar{P}=\frac{P1+P2}{2}$, with proportion of the number of cows ($P1$) = 0.34, the proportion for a level of significance ($P2$) = 0.5 and the mean of the prevalence ($\bar{P}$) = 0.2.

Therefore, the mean prevalence and standardized difference is 0.42 and - 0.324 respectively.

P = $(p_{1} + p_{2})$ / 2 = (0.34 + 0.05)/ 2 =0.20

= (0.34 – 0.05) / sqrt (0.20 (1- 0.20) =0.49

On the Nomogram, the standardized difference value of 0.49 to a power of 0.95 returned 200, this being the determined minimum number of cows with successive lactations needed for the study.

These 200 cows with successive lactations were proportionately distributed to the four wards, informed by the latest census report Kenya National Bureau of Statistics (KNBS) of 2020, that the dairy cattle population is 7,301 (Table 1). The distribution of the dairy cattle population in the wards is skewed: 62 percent (4,524) in Njoro; 19 percent (1,405) in Lare, 10 percent (720) in Kabatini, and 9 percent (652) in Lanet. To access the lactating cows, dairy farms were selected randomly from the list availed by the local extension officers who also facilitated access to the selected farms. On each farm visited, all cows present on the farm with successive lactations after drying off were examined. This is because smallholder dairy farms in the peri-urban area of Nakuru have a mode of just one cow on the farm (Kashongwe *et al.*, 2017). The owners of selected farms were individually contacted to explain the purpose of the study and request consent for their participation. This helped to ensure that informed consent is obtained from the farmers to guarantee their willingness to participate and share information details needed on their cows for this study.

Table 1: The proportional Distribution of Dairy Cattle Population, Lactating Cows and Sample Allocation to the Four Wards

Ward Proportional	Dairy cattle population	Lactating cow population	Proportion of lactating cows	Sample allocation
Njoro	4524	2352	0.62	130
Lare	1405	731	0.19	35
Lanet	652	339	0.09	17
Kabatini	720	774	0.10	18
Total	**7301**	**3797**	**1.00**	**200**

Source: Kenyan National Bureau of Statistics (2020)

3.2.3 Data Collection

In the cross-sectional observational survey, the objective was used to obtain a random sample of cows with successive lactations after drying off. On each farm, all cows with successive lactations after drying off that were present were examined by probing farmers for cow historical data on drying-off practices deployed, milk yield at the moment of commencing drying-off and in the subsequent early lactation. Further probing was made to identify cases of mastitis, udder leakages, and conception success on first service after calving, length in days to first insemination after calving (LCFI) and the dates of drying-off and inseminations and pregnancy diagnosis. The data capture tool used in availed in Appendix I.

Data verification during data collection involved direct observations, examining farm records, and probing the fertility history of individual cows in the herd. This was to improve the quality of data capture on milk production, cases of mastitis and udder health, and pregnancy diagnosis. Further, this enabled deriving daily milk yield, daily milk yield a month before the start of drying-off and at the drying-off moment, time of drying–off, length of the drying period, and cases of mastitis and udder leakages.

Figure 3 illustrates the conceptual framework that guided data collection process relevant to answering the four research questions of this study:

i. Is the mean milk yield at drying-off significantly different for the different cow drying-off practices that farmers deploy?

ii. Is the mean milk yield in the successive early lactation cycle significantly different for the different cow drying-off practices that farmers deploy?

iii. Are the cases of mastitis and udder leakages in the successive early lactation cycle significantly different for the different cow drying-off practices that farmers deploy?

iv. Is the mean number of days from calving- to- first insemination and cases of conception success in the successive early lactation cycle significantly different for the different cow drying-off practices that farmers deploy?

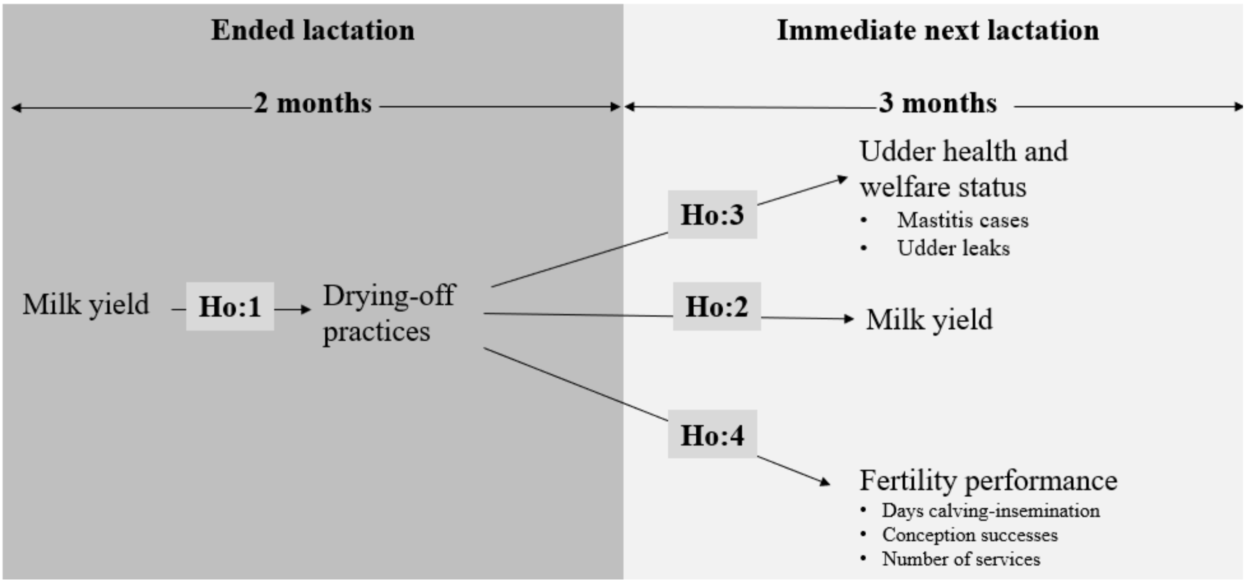

Figure 3: Conceptual framework

3.2.4 Data Analysis

The data was analyzed using two models: a general linear model for scale variable responses and a logistic regression model for binary outcome response variables. The general linear models were fitted to determine the level of milk yield at the moment of drying-off and during early successive lactation, number of days from calving to first insemination (D-cfi) for the different drying-off practices deployed, the breeds of cow and production systems. The fitted general linear model was specified as:

$$Y_{ijkl} = \mu + D_i + B_j + P_k + e_{ijkl}$$

where, Y_{ijkl} is the observation in ith drying-off practice of jth breed and kth production system μ is the overall mean

Di is the fixed effect of the i-th drying-off practice

Bj is the fixed effect of the j-th cow breed

Pk is the fixed effect of the k-th production system

εijkl is the random error with mean 0 and variance σ^2

The logistic Regression was fitted to estimates the odds ratio of being positive (binary outcome) for mastitis, udder leakage and conception on first service associated with drying-off practices, cow breeds, and production systems (Doe *et al*., 2024). The fitted logit models were specified in the expression:

$$\log(1 - pijk) = \beta_0 + \beta_1 D_i + \beta_2 B_j + \beta_3 P_K$$

where: $pijk$ is the probability of the binary outcome (1 or 0) for the i-th drying-off practice, j-th cow breed, and k-th production system

$\beta 1$is the regression coefficient for the i-th drying-off practice Di.

$\beta 2$ is the regression coefficient for the j-th cow breed Bj.

$\beta 3$ is the regression coefficient for the k-th production system Pk.

CHAPTER FOUR
RESULTS

4.1 Sample Description

The summary distribution of the sample farmers (Table 2). Of the 172 farmers sampled, over half (54.3 percent) were women and about two thirds (64 percent) had attained at least secondary level education. Results reveal that more than half of the farmers (55.5 percent) were managing their dairy cows at low intensification level (under free-grazing) while about one fifth (19.0 percent) were managing dairy cows at high intensification level (zero-grazing).

Table 2: Sample farmers and farms description

Variables	Frequency	Percent
Gender		
Female	93	54.3
Male	79	45.7
Educational level		
Adult education	13	7.8
Primary	49	28.4
Secondary	58	33.6
Post-secondary	52	30.2
Production Systems		
Free grazing	128	55.2
Semi-zero grazing	25	25.8
Zero grazing	19	19.0

The distribution of the cow sample population (n=232) is summarized in Table 3. The large dairy cattle breeds (Holstein Friesian and Ayrshire) predominated (78.9 percent) over the small dairy breeds (6.9 percent) and other breeds which included Sahiwal (14.2 percent). Predominantly, cows were Artificially Inseminated (89.7 percent) and majority conceived on the first service (70.3 percent). These sample cows had successive lactations of which about two thirds (66.8 percent) were dried off under 60 days, with first service after calving occurring between 59 and 151 days (Table 3). Cows were more frequently dried-off by a (gradual reduction of milking

Table 3: Description of the sample cows use recommended line spacing

Variables	Frequency	Percent
Length of drying of period		
≤60 days	155	66.8
> 60 days	77	33.2
Drying off practices		
Gradual reduction of milking	109	47.0
Complete stop of milking	51	22.0
Dry cow therapy	28	12.1
Stop feeding concentrates	24	10.3
Apply salt	11	4.7
Apply teat sealant	9	3.9
Breeds		
Large breeds	183	78.9
Other	33	14.2
Small breeds	16	6.9
Cases of mastitis		
Negative	191	82.3
Positive	41	17.7
Cases of udder leakage		
Negative	183	78.9
Positive	49	21.1
Sources of service		
Artificial Insemination	208	89.7
Natural bull	24	10.3
Conception success on first service		
No	69	29.7
Yes	163	70.3

(47%) or a complete stop of milking (22%). With the drying-off practices that farmers deployed, less than one fifth of the cows tested positive for mastitis (17.7%) or experienced udder leakage (21.1%).

The descriptive statistics of production variables of the sample cows (Table 4) reveal that on average, a cow with successive lactations was just one on a farm. The sample cows had large variation in milk yield. When drying-off, the average milk yield was 2.6 l/cow/day and in the early successive lactation, the average milk yield was 13.4 l/cow/day.

Table 4: Descriptive Statistics of Production Variable of the Sample Cows (n=232)

Variables	Units	Mean	Std Dev	Min	Max
Cow with successive lactation	number per farm	1.3	0.1	1	5
Milk yield at drying-off	Litres/cow/day)	2.6	1.9	0.5	13.0
Milk yield early successive lactation	Litres/cow/day	13.4	5.2	1.0	33.0
Calving- to- first insemination	day	91.9	12.8	5.9	15.1

4.2. Milk Yield at Drying-Off Associated with the Different Drying-Off Practices

Results in Table 5 presents the least square means of milk yield at the moment of drying-off associated with the different drying-off practices, breed of cow and production system. The least square means reveal large variation in milk yield t at drying-off ($p<0.05$) for the different drying-off practices, breeds and the production systems. Higher milk yielders were dried-off by applying teat sealant (5.3 litres/cow/day) while cows producing less than 5 litres/cow/day were dried-off by stopping feeding concentrate (4.8 l/day) or applying salt (3.2 litres/cow/day). Cows producing less than 3 litres/cow/day were dried-off by a gradual reduction in milking, a complete stop of milking or apply dry-cow therapy (2.2 -2.3 litres/cow/day). At drying-off, the larger breeds were producing more than 3 litres/cow/day while the small breeds (Guernsey and Jersey) and the other cattle breeds (Sahiwal and crossbreeds) were producing about 2.5 litres/cow/day. Cows managed at high intensification level (zero-grazing) were dried off when producing more than 3 litres/cow/day while those managed in low intensification level (semi-zero or free-grazing) were dried-off when producing less than 3 litres/cow/day.

Table 5:Milk Yield at the Moment of Drying-Off Associated with the Different Drying-Off Practices, Breeds of Cow and Production Systems

Variable	Observations	Least square means	Std. Error
Drying-off practices			
Gradual reduction of milking	109	2.3[a]	0.2
Complete stop of milking	51	2.4[a]	0.3
Dry cow therapy	28	2.3[a]	0.4
Stop feeding concentrate	24	3.2[b]	0.4
Apply salt	11	4.8[b]	0.6
Apply teat sealant	9	5.3[c]	0.3
Breed			
Large breeds	183	3.4[a]	0.2
Small breeds	16	2.6[b]	0.4
Other breeds	33	2.1[b]	0.5
Production System			
Free grazing	128	2.4[a]	0.3
Sem- zero- grazing	66	2.6[a]	0.3
Zero grazing	44	3.4[b]	0.3

Means with different letter superscript within a fixed factor differ at $p<0.5$

4.3 Milk Yield during Early Successive Lactation Associated with the Different Drying-Off Practices

The least square means of milk yield during early successive lactation cycle associated with the different drying-off practices, breeds of cow and production systems. Results in Table 6 reveal variation in mean milk yield ($p<0.05$) for the different drying-off practices, breeds and the production systems. During early successive lactation, cows previously dried-off by applying teat sealant, salt, stopping feeding of concentrate or a gradual reduction in milking produced more milk (≥14 litres/cow/day) than cows that had been dried-off by a complete stop of milking or dry cow therapy (10 - 12 litres/cow/day). The large dairy breeds produced more milk than the small dairy breeds and the other cattle breeds (16 vs 10-13 litres/cow/day). Under high dairy intensification (zero-grazing) cows were producing more milk during early successive lactation (14.9 l/day) compared to low intensification represented by free-grazing system (12.7 litres/cow/day).

Table 6: Milk Yield during Early Successive Lactation Associated with the Different Drying-Off practices, Breeds of Cow and Production Systems

Variable	Observations	Least square means	Std. Error
Drying-off practices			
Gradual reduction of milking	109	$14.4^{b, c}$	0.6
Complete stop of milking	51	10.4^{a}	0.8
Dry cow therapy	28	12.2^{a}	0.1
Stop feeding concentrate	24	15.3^{c}	1.1
Apply salt	11	15.0^{c}	1.5
Apply teat sealant	9	15.1^{c}	1.6
Breed			
Large breeds	184	16.1^{b}	0.5
Small breeds	15	13.3^{a}	1.3
Other breeds	33	10.2^{a}	0.9
Production System			
Free grazing	128	12.7^{a}	0.7
Semi zero- grazing	60	$13.7^{a,b}$	0.9
Zero grazing	44	14.9^{c}	0.9

$^{a, b, c}$ Means with different letter superscript within a fixed factor differ at $p<0.5$

4.4: Cases of Mastitis during Early Successive Lactation Associated with the Different Drying-Off Practices, Breeds of cow and Production Systems

The frequency of positive cases of mastitis with the odds ratio for mastitis cases associated with drying-off practice, cow breeds and production systems during early successive lactation. The occurrence of mastitis cases (Table 7) showed variation with the drying-off practices, breeds of cows and the production systems ($p<0.05$). Mastitis cases were less likely to occur with dry-cow therapy (odds ratio 0.12), gradual stopping of milking (odds ratio 0.22) or stopping feeding concentrate (odds ratio 0.14) relative ($p<0.05$) to complete stop of milking. Application of salt or teat sealant had no association with occurrence of mastitis case. The cows of large breeds (odds ratio 0.21) and other breeds (odds ratio 0.24) were less likely to have mastitis cases compared to the cows of small dairy breeds. Also, cows in high intensification management (semi-zero- and zero-grazing) were less likely to have mastitis cases (odds ratio 0.22 -0.29) compared to cows in low intensification management (free-grazing).

Table 7: Cases of Mastitis during Early Successive Lactation with Associated the Different Drying-Off Practices, Cow Breed and Production Systems

Factor Variable	Frequency	Percent positive	Odds ratio	95% CI	Sig
Drying-off Practices					
Apply salt	11	27	0.38	0.10—1.41	0.147
Apply teat sealant	9	33	0.50	0.13—1.20	0.327
Complete stop of milking	51	11.6	Ref		
Dry cow therapy	28	10.7	0.12*	0.04—0.40	0.001
Gradual reduction of milking	109	21.1	0.27*	0.17—0.42	0.001
Stop feeding concentrate	24	12.0	0.14*	0.04—0.48	0.002
Breeds					
Large breed	184	17.4	0.21*	0.14—0.31	0.001
Other breeds	33	15.0	0.24*	0.10—0.63	0.004
Small breed	15	26.7	Ref		
Production Systems					
Free grazing	128	15.2	Ref		
Semi-zero-grazing	60	18.3	0.22*	0.12—0.43	0.001
Zero grazing	44	22.7	0.29*	0.15—0.59	0.001

*Significant association $p<0.05$.

Results in Table 8 presents the percent positive cases of udder leakages and odds ratio estimates associated with the different drying-off practices, breeds of cows and production systems. Results indicate variation ($p<0.05$) in udder leakage positive cases with the drying-off practice that farmer deployed, breed of cow and the production system. The odds ratio suggest that udder leakage cases were less likely to occur with dry-cow therapy (odds ratio 0.12), gradual reduction of milking (odds ratio 0.29) and stopping feeding concentrates (odds ratio 0.26) compared to complete stop of milking. Application of salt or teat sealant showed no association with udder leakage cases. Also, cases of udder leakage were less likely among the large dairy breeds (odds ratio 0.27) and among other breeds (odds ratio 0.22) relative to small dairy breeds. The odds ratio further indicate that cases of udder leakages were less likely for cows managed under high intensification (odds ratio of 0.12 to 0.33 in semi-zero and zero-grazing) in comparison to cows managed in low intensification (free-grazing).

Table 8: Cases of Udder Leakage during Early Successive Lactation Associated with the Different Drying-Off Practices, Breeds of Cow and Production Systems

Factor Variable	Frequency	Percent positive	Odds ratio	95% CI	Sig
Drying-off Practices					
Apply salt	11	18.2	0.22	0.05—1.03	0.054
Apply teat sealant	9	33.3	0.50	0.13—2.00	0.327
Complete stop of milking	51	21.6	Ref		
Dry cow therapy	28	10.7	0.12*	0.04—0.40	0.001
Gradual reduction of milking	109	22.9	0.29*	0.19—0.46	0.001
Stop feeding concentrate	24	20.8	0.26*	0.10—0.71	0.008
Breeds					
Large breed	184	21.2	0.27*	0.19—0.38	0.001
Other breeds	33	18.0	0.22*	0.09—0.54	0.001
Small breed	15	26.0	Ref		
Production Systems					
Free grazing	128	16.0	Ref		
Semi-zero- grazing	60	28.3	0.12*	0.07—0.200	0.001
Zero grazing	44	25.0	0.33*	0.17—0.66	0.002

*Significant associations p< 0.05

4.6 Cow Fertility Performance during Early Successive Lactation Associated with the Different Drying-Off Practices, Breeds of cow and Production Systems.

Odds ratio of conception success on first insemination during early successive lactation for the different drying-off practices, breeds of cow and production systems. Table 9 presents the likelihood of conception success varied (p<0.05) with the cow drying-off practice, breed of cow and production system. Conception success was more likely for cows dried off by a gradual stop of milking (odds ratio 2.41) or by dry-cow therapy (odds ratio 3.67) than the cows dried off by a complete stop to milking

Table 9: Odds Ratio of Conception Success on First Insemination during Early Successive Lactation for the Different Drying-Off Practices, Breeds of Cow and Production Systems

Factor Variable	Frequency	Percent positive	Odds ratio	95% CI	Sig
Drying-off Practices					
Apply salt	11	72	2.67	0.71—10.05	0.147
Apply teat sealant	9	88	8.00	1.01—63.96	0.050
Complete stop of milking	51	62.7	Ref		
Dry cow therapy	28	87.5	3.67*	1.49—9.04	0.005
Gradual reduction of milking	109	70.6	2.41*	1.59—3.63	0.001
Stop feeding concentrate	24	66.6	2.00	0.86—4.67	0.109
Breeds					
Large breeds	184	70.1	2.35*	1.71—3.22	0.001
Other breeds	33	60.6	1.43	0.72—2.83	0.306
Small breeds	15	93.3	Ref		
Production Systems					
Free grazing	128	73.4	Ref		
Semi-zero grazing	60	56.6	1.31	0.79—2.18	0.303
Zero grazing	44	79.54	3.89*	1.87—8.09	0.001

*Significant associations p<0.05

Drying off cows by stopping concentrate feeding, applying salt or teat sealant had no influence on likelihood of conception success. The odds ratio estimates further indicate that conception success was more likely among cows of large dairy breeds (odds ratio 2.35) relative to small breeds and also more likely (odds ratio 3.89) for cows in high intensification management (zero-grazing) than cows in low intensification management (free-grazing)

Least square means of the number of days from calving to first insemination (D-cfi) was 91.9 days and showed a variation ($p<0.05$) with the different drying-off practices, breeds of cow and production systems.

Table 10: Days From Calving to First Insemination (D-cfi) by the Different Drying-Off Practices, Cow Breeds and Production Systems

Variable	Observations	Least square means	Std. Error
Drying-off practices			
Gradual reduction of milking	109	87.5^{c}	9.43
Complete stop of milking	51	93.3^{d}	7.36
Dry cow therapy	28	81.14^{b}	9.90
Stop feeding concentrate	24	76.0^{a}	9.43
Apply teat sealant	11	86.4^{c}	14.77
Apply salt	9	100.4^{e}	13.8
Breed			
Large breeds	184	87.6^{a}	6.3
Small breeds	15	64.7^{b}	7.8
Other breeds	33	96.2^{c}	7.65
Production System			
Free grazing	128	82.5^{a}	4.2
Semi- zero grazing	60	91.7^{b}	8.3
Zero grazing	44	94.5^{c}	11.5

Means with different letter superscript within a fixed factor differ at $p<0.5$

Results in (Table 10) above suggest that cows dried off by stopping feeding concentrate were inseminated earlier (76 days) while those that were dried-off by a complete stop of milking or salt application were inseminated later (93 -100 days). Cows that had been dried off by application of teat sealant, dry cow therapy or a gradual reduction in milking were inseminated in between (81 -87 days). First insemination after calving was earlier for small dairy breeds (64.7 days) than for large breeds (87.6 days), while insemination was earlier under low intensification (82.5 days) than under high intensification (≥ 91 days).

CHAPTER FIVE
DISCUSSION

5.1 Milk Yield at Drying-Off and during Early Successive Lactation Associated with the Different Drying-Off Practices

This study generates factors that influence the level of milk yield during drying-off and early successive lactation cycle for the different cow drying-off practices, cow breeds and production systems in dairy farming, specifically in the Nakuru Peri-urban area 172 farms were visited and 232 cows in successive lactation were sampled. Of the farms visited 54.3% were women and about the two third 64% had attained at least a secondary level of education. The progress and the development of a country depend on the status and enhancement of its women, not only because they represent about half of the population, but also favorably influence the progress of the overall population (Desai & Upadhyay, 2011). It is impossible to achieve sustainable development without the active participation of women in all sectors, including family, society, and the economy women's participation is required for their development (Egoh, 2019).

In the study sample, about half of the farmers (44.8 percent) were managing their cows at high intensification (semi-zero- and zero-grazing systems), which indicates a trend to intensify dairy production in the peri-urban areas. In an earlier study of the same sample, Migose *et al.* (2022) concluded that dairying in peri-urban areas needs interventions that support production intensification and commercial production, with high input use for high output and high productivity per cow. This is because of better market access and higher milk prices in the peri-urban areas, but whether this also encourages good husbandry practices in cow drying-off practices has not attracted research. In the sample farms, a herd often had just one lactating cow, which present challenging management decision for these farmers regarding which is the optimal level of milk yield when to dry-off a cow because milk is a source of continuous stream of income (Bebe *et al*., 2003). Though farmers deployed a range of drying-off practices, more than two thirds (69 percent) deployed a gradual reduction of milking or complete stop of milking. However, the most frequent practice was a gradual reduction of milking (47 percent), likely reflecting that the practice allows for a gradual reduction in daily stream of income when milking just one cow, a production circumstance characterizing these herds. In contrast to present study, others report that the most frequently employed drying-off practices is antibiotic dry cow therapy, but this deviates from the trend to minimize antimicrobial usage. Other drying-off practices such as dry cow therapy, a stop to feeding concentrate, applying salt or teat sealant were less frequently practiced (4 to 12 percent) in the study sample. A good drying-off practice should not adversely impact on cow productivity and health. Therefore, empirical evidence of the association that the different drying-off practices have with milk yield at the moment of drying-off and during early successive lactation is necessary to inform management decision (Niemi *et al.*, 2021).

Studies on dairy cow management emphasize the importance of proper drying protocols and their impact on subsequent lactation performance have reported by Barkema *et al.* (2015), genetic selection as well as advances in food and dairy cow management can increase average milk production per cow, which present challenging management decisions about choice of drying-off practice (Stefanon *et al.*, 2002; Zobel *et al.*, 2015). Drying-off in the study sample was frequently (68 percent) before 60 days to expected calving date. Early drying-off may have a favorable influence on milk yield in the successive lactations (Huzzey *et al.* (2007). However, Pezeshki *et al.* (2010) observed a decrease in milk production as a result of early drying-off period and attributed this to less developed mammary gland. Rutten *et al*. (2013) have reported that consistency in milk yield across the drying-off periods may indicate stable conditions or effective management practices.

The first two research questions that this study answered was whether mean milk yield at drying-off and during successive early lactation cycle significantly differs between different cow drying-off practices that smallholder farmers deploy in the peri-urban herds. Milk yields were estimated adjusting for breed of the cow and management intensification conditions in which the cow was producing milk. Drying-off practice, breed and intensification all had significant association ($p<0.05$) with the mean milk yield at drying-off and during early successive lactation cycle. Though the most frequent drying-off practices deployed, a gradual reduction of milking and a complete stop of milking were deployed for low yielding cows producing less than 3 litres/cow/day. This further supports the explanation that with one lactating cow in a herd, drying-off practice is likely deployed to allow for a gradual reduction in daily stream of income. The other drying-off practices including stopping feeding concentrates, applying teat sealant or salt were deployed for high milk yielders producing more than 3 litres/cow/day. It is likely that farmers consider these drying-off practices as effective for high milk yielders. The result suggests that certain drying-off practices deployed have a strong association with milk yield at moment of drying-off, implying that farmer consider milk yield on their decision to deploy a given dry-off practice. This implies that milk yield of 3 litres/day/cow is an indicative threshold for decision over which drying-off practice would be best to deploy.

At the moment of drying off, large breeds were producing more than 3 litres/cow/day while small breeds (Guernsey and Jersey) and other cattle breeds (Sahiwal and crossed breeds were producing less than 3 litres/ cow/day. This breed variation in milk yield at drying-off is a reflection of varying potential milk yield of the breeds because large breeds have higher potential milk yield relative to the small breeds and the other breeds. This observation concurs with those of Plii *et al.* (2021) that breed has a substantial influence on milk output, both directly and in combination with other parameters. At drying-off, cows managed under higher intensification level (zero-grazing) were dried off when producing more than 3 litres/cow/day while those managed at a low intensification level (semi-zero or free-grazing) were dried off when producing less than 3 litres/cow/day. This is a phenomenon also observed with drying-off practices, further supporting that milk yield of 3 litres/day/cow is an indicative threshold for decision to dry-off a cow. In the study sample, large breeds predominated (78.9%) over the small breeds (6.9%) and other breeds which included Sahiwal (14.2%). Farmers prefer large breeds for their high milk yield potential, which they associate with more incomes, as milk marketing in Kenya is on volume basis. The explanation corroborates with findings in the Kenya highlands (Bebe *et al.,* 2003) where large breeds dominated (62 percent) over small dairy breeds (16 percent) and over other breeds (22 percent)

Compared to other drying-off practices, Wayne and Peterson (1933) have recommended a complete stop of milking as best drying-off practice because cows produce a large amount of milk in the successive lactation. During early successive lactation, cows previously dried off by applying teat sealant and salt, stopping feeding of concentrate or gradual reduction of milking produced more than 14 litres/cow/day while those that had been dried off by a complete stop of milking or dry cow therapy produced less than 14 litres/cow/day. The result suggests that drying-off practice has influence on subsequent milk yield during early successive lactation. The physiological mechanism of these drying-off practices may be at play. For the study sample, farmers would realize higher milk productivity with application of teat sealant and salt, stopping feeding of concentrate or gradually reducing milking.

While the large dairy breeds produced more than 15 liters/cow/day of milk, the small dairy breeds together with the other cattle breeds produced less than 15 liters/cow/day (16 vs 10-13 litres/cow/day). In this study sample therefore, large dairy breeds produced at least 3 litres/cow/day of milk more than the small dairy breeds and other breeds. This is consistent with genetic potential for higher milk yield among the large dairy cattle breeds. With intensified dairy management (zero-grazing) cows produced about 15 litres/cow/day of milk during early successive lactation (14.9 1/day) and less than 15litres/cow/day with low intensification in free-grazing systems (12.7 litres/cow/day). This indicates that at high intensification, husbandry practices are better and more effective than at low intensification.

These results of this study show that good draying-off practice at drying-off period will increased milk yield at the subsequent early lactation cycle and prevent cow udder health and increase the intensification of dairy management. The implication is that intensification of dairy management encouraged farmers to practice good drying-off practice that will enhanced milk yield in successive lactation and promote cow udder health. These required requisite training and awareness for dairy farmers on the importance of drying-off practices and empowering women in the peri-urban areas can significantly enhance milk production, cow health and more importantly economic sustainability. Results from this research are relevant for comprehensive framework for policymakers, extension delivery service, to motivate dairy farmers to practices good management practices that contributes to SDG'S.

5.2 Cow Udder Health during Early Successive Lactation Associated with the Different Drying-Off Practices

Considerations about cow udder health outcome is an important component in cow drying-off practice that when neglected or given inadequate husbandry can adversely affect cow welfare status in the subsequent early successive lactation. Mastitis is the most common infectious disease in dairy cattle, with global economic damages estimated to be more than USD 40 billion per year (Paramasivam *et al.,* 2023). Udder health is critical for sustainable milk production. Mastitis is not only a medical challenge but can affect the milk quality, cow performance, and use of antibiotics per farm. Therefore, maintaining cow udder health is essential for producing high-quality milk. However, udder infections and difficulties can lead to higher somatic cell counts (SCC), incidences of mastitis, and bacterial contamination, which can result in lower milk quality and less milk production.

To follow on concerns about udder health, this study selected cases of mastitis and udder leakages for proxy indicators of cow udder health outcome. A research question was answered as to whether cases of mastitis and udder leakages in the successive early lactation cycle can be significantly associated with cow drying-off practices that farmers deploy?

Associations were estimated with odds ratio in a binary logistic regression, adjusting for breed of cow and management intensification under which the cow was producing milk.

Results showed significant associations ($p<0.05$) of cases of mastitis and udder leakages with cow drying-off practice, breed and intensification of dairy management. Setting a complete stop of milking as the reference in the binary logistic regression, it was found that mastitis cases were less likely to occur with gradual stopping of milking (odds ratio 0.22), stopping feeding concentrate (odds ratio 0.14) or dry-cow therapy (odds ratio 0.12). The results suggest that mastitis cases would be higher for cows dried-off with a complete stop of milking, which was the second most frequent drying-off practice by smallholder farmers in this study. Because mastitis prevalence in the peri-urban smallholder dairy herds can exceed 80 percent (Bantawa *et al.,* 2019; Kashongwe *et al.,* 2017). Choice of drying-off practice can be considered one of the explanatory factors for high mastitis prevalence in these herds. High mastitis prevalence is indicative of poor husbandry practices, especially udder hygiene practices, and is a predisposing factor for development of antimicrobial resistance, which is associated with frequent treatment of mastitis infections (Mogotu *et al.,* 2022). In the study sample, application of salt or teat sealant for cow drying-off had no association with occurrence of mastitis case, which suggest a good practice for adoption by farmers.

When drying-off practices are poorly performed or overlooked, they can have a negative influence on cow health, welfare status, and fertility performance in the subsequent lactation cycle. According to Pinedo *et al*. (2012) stated, that roughly 60% of all early lactation mastitis episodes originate during the dry period. To avoid new infections before calving and treating existing infections, dairy cows should be cleaned off properly (Klopčič *et al.,* 2011). Reducing milking intervals at drying off and calving can minimize the cases of mastitis and udder leakage given that continuous milking of cows can lead to severe teat injury or an abnormal streak canal and it is important to observe the safety precaution method during milking the cows simply because mastitis is a bacterial infection that can transmit to cow during milking the teat canal should be sterilized before milking to minimize the incidence of bacterial in general, it all leads to effective management methods. Higgins *et al*. (2024) veterinarians are advocating for dry cow therapy and teat sealant as the best drying practices. Their reason is these drying-off practices protect cows from pathogens during the drying time and reduce the risk of mastitis during the subsequent lactation cycle. Some studies recommend application of dry cow treatment with teat sealants and making housing changes as best strategy to dry cows, and abrupt or gradual procedure give same results (Sang *et al.,* 2021). In the study sample, mastitis cases were less likely occurrence with cows of large breeds (odds ratio 0.21) and other breeds (odds ratio 0.24) compared to the cows of small dairy breeds. This implies that small breeds experienced higher mastitis infections, yet they produce less milk, which should reduce the risk of mastitis. This could suggest a possibility of differential breed husbandry deployed by farmers. Supporting this explanation is the observation that cows managed at high intensification (semi-zero- and zero-grazing) were less likely to experience mastitis case (odds ratio 0.22 -0.29) compared to cows managed at low intensification management (free-grazing). This somewhat fits with the conclusions reached by Migose *et al.* (2022) that production intensification is achieved with high input use for high output and high productivity per cow. With the increased intensification in the dairy sector, it's vital for smallholder dairy farmer to practice best practice that are accordant with empirical evidence to maintain cow udder health and enhance milk yield and fertility. Early identification of the cow udder health problem requires effective individual cow monitoring. For optimal outcome, the basic purpose of udder health management needs to ensure the cleanliness of the teat before milking and reduce the milking frequency of the cow at drying-off and medical interventions.

Mastitis is one of the most common dairy diseases today. Furthermore, it not only causes significant economic loss, but it is also a painful and uncomfortable condition that has a direct impact on the cow's well-being. Improved management and farm cleanliness techniques can help avoid new instances of mastitis while also reducing antibiotic use. Gorodov *et al*. (2019) states that *Staphylococcus aureus* is one of the most common causes of persistent mastitis and is typically a subclinical infection. Infected udders, teat canals, and teat lesions are the primary reservoirs, however, teat skin, muzzles, and nostrils have also been identified. Mastitis has detrimental effects on milk yield, cow performance, profitability, welfare, and longevity (Puerto *et al.,* 2021). Similar research by Sumon *et al.* (2020), has shown that bacterial intra-mammary infection (IMI) is the leading cause of cow mastitis.

For udder leakage, positive cases were less likely with dry-cow therapy (odds ratio 0.12) and gradual reduction of milking (odds ratio 0.26) while application of salt or teat sealant was not associated with udder leakage cases. The results do suggest that application of salt or teat sealant would be beneficial to minimizing udder leakage cases while a complete stop of milking would not. The breed differences exhibited in cases of udder leakage showed less likelihood among the large dairy breeds (odds ratio 0.27) and other breeds (odds ratio 0.22) relative to small dairy breeds. This implies different breeds require different drying-off practices and therefore the extension service need package appropriate messages to farmers.

The evidence generated in this study does not support that the risk of udder leakage is directly linked to high milk yield potential of the breed, because the likelihood of udder leakage was less among the large dairy breeds relative to small dairy breeds. Hoeij *et al.* (2016), Tucker *et al.* (2009) and Zobel *et al.* (2013) identify two important times of the dry period when udder health is at risk. These are the first week after drying off and the week before calving. During the first critical stage, the udder's natural defense mechanism forms a keratin block in the teat canal. In the second stage, before calving, this plug gradually dissolves in preparation for lactation.

The keratin plug keeps microorganisms from entering the teat canal during the dry period. According to research conducted El-Sayed *et al.* (2021), employing an internal teat sealant in conjunction with antibiotics minimizes the incidence of new infections. This product replicates the natural keratin plug, preventing bacteria from entering the teat canal (Mcpland *et al.,* 2019). In low Somatic Cell Count (SCC) cows, an internal teat sealant can be used alone; however, extra hygiene precautions must be followed when giving the teat sealant. After calving, it is recommended to remove the internal teat sealant to prevent the plug from entering the milking system. This practice requires high level husbandry practices, which is rare in smallholder dairy herds, but improves with intensification of dairy management. In detail, this study generates the appropriate drying-off practices in maintaining cow udder health and mitigating the incidence of mastitis and udder leakages. Dry cow therapy and gradual reduction of milking and high intensification dairy management are effective and efficient strategies farmers should employ to enhance milk production, cow health and welfare status. Therefor implementing these practices will improve the production and productivity and the overall management of the dairy farm, while mitigating economic losses and contribute to reduction of antimicrobial resistance.

5.3 Cow Fertility Performance during Early Successive Lactation Associated with the Different Drying-Off Practices

Reproductive performance is the primary concern of the modern dairy industry worldwide, as it determines the profitability of a dairy farm. Poor reproductive performance is one of the leading causes of culling in dairy herds. Because it affects the amount of milk produced per cow per day of herd life, the cow's longevity in the herd, and the costs of herd replacement, breeding, and veterinary treatment and medications. Fertility is one of the major factors affecting the efficiency of any dairy herd. It can account for one of the major costs of production and also represents an area where significant improvements can be made. Calving interval is a popular fertility measure because calving dates are readily available in milk tracking programmes, and calving interval represents the cumulative total of events that eventually contribute to successful calving. The calving interval can be computed and analyzed using these dates to determine the fertility of cows kept on commercial dairy farms. The Calving interval has been utilized in various research to investigate the genetics of fertility and its link to other regularly reported production parameters. Calving interval and milk yield are undoubtedly substantially connected negatively, and LeBlanc (2010) proposed multivariate survival analysis of reproductive variables as the sole genuine method for determining individual cow fertility. Although this method provides an unbiased assessment of a cow's fertility, it is not yet practicable with commercial dairy records in most cases. Furthermore, the quantitative genetic technique utilized here considers all genetic impacts on a trait, regardless of origin. As a result, the indirect effect of milk output has a valid influence on the calving interval in this situation. Cow fertility, however, is determined by a variety of parameters, including semen quality, proper management of semen straws, AI-breeding technology, and insemination time. Estrus detection. Accurate estrus detection is critical for successful fertilization.

For farmers, return to estrus is an important indicator of reproductive performance of lactating cow. This is because earlier return to estrus post calving has influence on calving interval. Extension recommendations has favored inseminations within 90 days' post calving but successful conception requires adequate feeding. In this study, cow fertility was proxies with the conception success and the length of days from calving to first insemination. This was easier for farmers to recall being short period because the subject had an immediate successive lactation. The research question was ton answer whether the mean number of days from calving- to- first insemination and cases of conception success in the successive early lactation cycle significantly differs by the different cow drying-off practices that farmers deploy. Estimates were adjusted for breed of the cow and the management intensification under which the cow was producing milk.

It was found that the mean number of days from calving- to- first insemination and cases of conception success in the successive early lactation cycle was significantly variable ($p<0.05$) with the cow drying-off practices that farmers deployed, the breed of the cow and dairy intensification. First insemination post calving was earlier for cows that had been dried off by stopping feeding concentrate (76 days) than those cows that had been dried-off by a complete stop of milking or salt application (93-100 days) or by application of teat sealant, dry cow therapy or a gradual reduction in milking (81-87 days). The difference in the length of days to first insemination corresponds to about one estrous cycle, implying a likelihood of better heat detection when cows were dried-off by stopping feeding concentrate. Cows require adequate energy and well-balanced nutrients of amino acids, vitamins, and minerals to begin cycling and exhibiting estrus. If there is a delay in exhibiting estrous, the conception success suffers during insemination. Wiltbank *et al.* (1962) discovered that cows fed high-energy diets, particularly after calving, had higher pregnancy rates. These would suggest cows that been dried-off by stopping feeding concentrate had deposited adequate energy to sustain them during early successive lactation.

Season and environmental factors also influence pregnancy rates (Cardoso- & Drackley, 2014). Heat stress is experienced by the animal during extremely hot conditions, resulting in a considerable drop in conception rates (Das *et al.,* 2016). Finally, the cow age influences both pregnancy percentage and calving interval. The calving interval is the time between two successive carvings in the same female and is commonly used as a metric of reproductive efficiency (Murphy (Murpy & Sreenan, 2006). First-calf heifers frequently have a longer calving interval and later calve down. Other research has revealed that cows who are two years old or older had lower conception rates than cows of intermediate age (Bitencort *et al.,* 2020; Diskin & Morries, 2008; Evans & Willian, 2011), due to higher energy requirements following their first calving. Heifers require more energy for growth and maintenance than adult cows, leaving them with less energy for reproductive tasks (Esposito *et al.,* 2014). Predominantly cow servicing was by artificial insemination (89.7 percent) and rarely by bull natural mating (10.3 percent). This corroborates field observation report of USDA (2020) that 89 percent of the dairy herds are served with artificial insemination. A major constraint in using artificial insemination technology is efficient detection of cows in heat. In the study sample, seven in ten cows served (70.3 percent) conceive with first services, suggesting good heat detection ability and adequate cow feeding by the farmers and good insemination skills by inseminators. This a contrasting observation from other reports that these husbandry practices are poorly implemented in smallholder dairy herds (Mwanga *et al.,* 2019).

Use of artificial insemination technology offers many benefits to smallholder farmers keeping just one or two cows for milk to earn income and high food for family nutrition. One of the primary benefits is the ability to use semen from improved genetically superior bulls, allowing farmers to make tangible mating decisions about which bull will mate their cows.

Another important benefit is the ability to reduce the number of bulls kept on farms which lowering maintenance costs and increases profitability in addition to improving worker safety

Early successful insemination which was less than 85 days in the sample cows, means a shorter calving to insemination gap (Gebele & Kassa, 2020). In general, it is assumed that a one-year calving interval is a good indicator of dairy herd fertility and profitability (Temesgen *et al.,* 2022). To achieve this calving interval, a postpartum cow must restart ovarian activity early, be discovered in heat, be mated, and conceive within 85 days of calving, while providing considerable amounts of milk (Wathes *et al.,* 2014). Consequently, these good husbandry practices enabled successful earlier first insemination post calving, which was earlier for small dairy breeds (64.7 days) than for large breeds (87.6 days). But earlier insemination under low intensification (82.5 days) than under high intensification (≥ 91 days) would suggest some management strategy of deliberately delaying mating or less successful heat detection relative to low intensification. In summary the study highlights the effects of drying-off practice on reproductive performance of dairy cow. The results from this study indicates that effective drying-off practices and optimizing nutritional management, will improve the chances of heat detection and AI practices and enhancing balanced intensification will improve the reproductive performance and reduced days of calving- interval and enhance the overall profitability of the farm. These results from this study will provide valuable insights for extension delivery service, policymakers and dairy farmers to practice efficient reproduction management practices that will significantly contribute to profitability and sustainability of the dairy farm.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

i. Mean milk yield estimates at drying-off significantly differed among the different cow drying-off practices that farmers deployed, high milk yield (5.3liters/cow/day) was associated with teat sealant, while cow producing less than (5litres/cow/day) were dried off by stop feeding concentrates or applying salt.

ii. Mean milk yield estimates in early successive lactation cycle significantly differed among the different cow drying-off practices that farmers deployed, gradual reduction of milking, application of teat sealant or salt, and stop feeding concentrate produced higher milk yields (≥14 liters/cow/day) compared to cow dried-off by a complete stop of milking or dry cow therapy.

iii. Cases of mastitis and udder leakages in the successive early lactation cycle significantly differed among the different cow drying-off practices that farmers deployed, mastitis and udder leakages cases were less likely to occur with dry cow therapy and gradual reduction of milking compare to stop feeding concentrate and complete stoppage of milking while application of salt and teat sealant had no association with occurrence of mastitis and udder leakages cases during early successive lactation cycle.

iv. Mean number of days from calving-to- first insemination and cases of conception success in the successive early lactation cycle significantly differed among the different cow drying-off practices that farmers deployed, cow dried-off by stopping concentrate were inseminated earlier(76days) while those that were dried-off by a complete stop of milking or salt application were inseminated (93-100days) cow that had been dried-off by application of teat sealant, dry cow therapy or gradual reduction in milking were inseminated in between(81-87days) and conception success was more likely to occur with cow dried-off by gradual reduction of milking and dry cow therapy compare to complete stop of milking, while stop feeding concentrate, apply salt and teat sealant had no influence on conception success.

6.2 Recommendations

i. Farmers needs carefully plan about drying-off practices. High-yielding cows that produced (5+ liters/day) should dried off by apply teat sealant to optimize milk production, while cows producing less than 5 liters/day may respond better to stop feeding concentrate.

ii. To optimize milk yield during early success lactation farmers should dried their cow by gradual reduction of milking, application teat sealant or stop feeding concentrate.

iii. To effectively manage and maintain udder health in dairy cows, smallholder dairy farmers should dried their cows by gradual reduction of milking, dry cow therapy or apply teat sealant which prove to be the most effective drying-off practice with high milk yield at early successive lactation cycle.

iv. From calving date to first insemination farmers should inseminate their cows in between (81-87) from calving to have high chances of conception success during the first insemination.

6.3 Further studies

i. Further research could go deeper into understanding the mechanisms underlying these effects, as well as investigate other factors that may influence milk production during the drying-off period and early successive lactation.

ii. Further research with a broader set of variables and a larger sample size may provide further insight into the complex dynamics influencing udder health in dairy production systems.

iii. Additional study using larger sample sizes, longitudinal studies, and additional variables may provide more insight into the complex dynamics impacting dairy cow management and fertility performance.

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APPENDICES

Appendix A: Questionnaire

EGERTON UNIVERSITY

DEPARTMENT OF ANIMAL SCIENCE

Questionnaire /data collection sheet

Consent seeking

The purpose of this questionnaire is to analyze current knowledge on cow drying-off management practices used by smallholder dairy farmers in the Nakuru peri-urban area. The information gathered is solely for academic purposes related to the MSc study program requirements. Participation is entirely voluntary. I pledge to treat all information provided secretly.

I, ………………………………………………………….., the rightful owner of dairy cattle, hereby do voluntarily give consent to participate in the study as explained to me.

Signature: ………………. Date: ………………………..

Name of the interviewee………………………………………………….

Date: ……………………

Section A: Farmer identity

Ward	Gender of herd owner	Education level	Total cattle	Total lactating cows	Production systems
Wards: 1=Lare 2=Njoro 3=Lanet 4=Kabatini	1=Male 2=Female	1=Adult education 2=Primary 3=secondary 4=post-secondary	1=Free grazing 2=Free grazing and zero grazing sometimes 3=Zero grazing entirely		

Section B: Cow drying-off practices

Cow ID #	Breed	Parity	Drying off practice	Milk yield at drying off started	Date last drying off started	Date last drying off ended	Milk yield at last drying off end	milk yield in present lactation at start	Method of insemination (1=bull, 2=AI)	Was insemination successful? (1=yes; 2=No)	Last calving date	Date when first inseminate after drying -off	Method of insemination (1 yes) (2 no)	Was insemination successful (1 yes) (2 no)	Mastitis case in present lactation (1 yes) (2 no)	Udder leakage in present lactation (1 yes) (2 no)	Cow became sick (1yes) (2 no)
1																	
2																	
3																	
4																	
5																	

Breeds code.

1. **Holstein Friesian**
2. **Ayrshire cattle**
3. **Jersey cattle**
4. **Guernsey cattle**

Drying-off practices

1. **Stop feeding concentrate**
2. **Gradual reduction of milking**
3. **Complete stop of milking**
4. **Mastitis monitoring**
5. **Dry cow therapy**
6. **Teat sealant**

Appendix B: Data Sheet

```
/HIDDEN IGNORE=YES.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
AUTORECODE VARIABLES=Production_system
  /INTO Productionsystem2
  /PRINT.
```

Production system into Productionsystem2

Old Value	New Value Value Label
Free Grazing	1 Free Grazing
Free Grazing& Zero Grazing	2 Free Grazing& Zero Grazing
Zero Grazing	3 Zero Grazing

```
AUTORECODE VARIABLES=Breeds
  /INTO Breeds2
  /PRINT.
```

Breeds into Breeds2

Old Value	New Value Value Label
Large Breed	1 Large Breed
Other	2 Other
Small Breed	3 Small Breed

```
AUTORECODE VARIABLES=DryingoffPractice
  /INTO Dryingoffpractice2
  /PRINT.
```

DryingoffPractice into Dryingoffpractice2 (Drying-off-Practice)

Old Value	New Value Value Label
Apply Salt	1 Apply Salt

Apply Teat Sealant 2 Apply Teat Sealant

Complete Stop of Milking 3 Complete Stop of Milking

Dry Cow Therapy 4 Dry Cow Therapy

Gradual Reduction of Milking 5 Gradual Reduction of Milking

Stop Feeding Concentrate 6 Stop Feeding Concentrate

AUTORECODE VARIABLES=Casesofmastitis

/INTO Casesofmastitis2

/PRINT.

Casesofmastitis into Casesofmastitis2 (Cases of mastitis)

Old Value New Value Value Label

Positive 1

Negative 0

Casesofudderleackages into Casesofudderleackage2 (Cases of udder leackages)

Old Value New Value Value Label

Positive 1

Negative 0

```
NEW FILE.
DATASET NAME DataSet2 WINDOW=FRONT.
WEIGHT BY count.
LOGISTIC REGRESSION VARIABLES udder
  /METHOD=ENTER production
  /CONTRAST (production)=Indicator
  /PRINT=CI(95)
  /CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).
```

```
DATASET ACTIVATE DataSet1.
NEW FILE.
DATASET NAME DataSet3 WINDOW=FRONT.
WEIGHT BY countd.
LOGISTIC REGRESSION VARIABLES mastitisd
  /METHOD=ENTER drying
  /CONTRAST (drying)=Indicator
  /PRINT=CI(95)
```

```
  /CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).
WEIGHT BY countb.
LOGISTIC REGRESSION VARIABLES mastitisb
  /METHOD=ENTER breed
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  /PRINT=CI(95)
  /CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).
NEW FILE.
DATASET NAME DataSet2 WINDOW=FRONT.
WEIGHT BY count.
LOGISTIC REGRESSION VARIABLES udder
  /METHOD=ENTER production
  /CONTRAST (production)=Indicator
  /PRINT=CI(95)
  /CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).
  /PRINT.
AUTORECODE VARIABLES=Sourceofservice
  /INTO Sourceofservice2 /PRINT.
Sourceofservice into Sourceofservice2 (Source of service)
Old Value New Value Value Label
AI              1 AI
Bull            2 Bull
AUTORECODE VARIABLES=Darying_offintervals
  /INTO Dryingoffinterval2
  /PRINT.
Darying_offintervals into Dryingoffinterval2 (Darying_off(intervals))
Old Value         New Value Value Label

60 days and below         1 60 days and below
Above 60                  2 above 60
AUTORECODE VARIABLES=Concivedonfirstservice
  /INTO Concivedonfirstservice2
  /PRINT.
Concivedonfirstservice into Concivedonfirstservice2 (Concived on first
   Service)
Old Value New Value Value Label
```

No 1 No

Yes 2 Yes

```
LOGISTIC REGRESSION VARIABLES Conceptio
  /METHOD=ENTER production
  /CONTRAST (production)=Indicator
  /PRINT=CI(95)
  /CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).

LOGISTIC REGRESSION VARIABLES Conceptio

  /METHOD=ENTER breed

  /CONTRAST (breed)=Indicator

  /PRINT=CI(95)

  /CRITERIA=PIN(0.05) POUT(0.10) ITERATE(20) CUT(0.5).

DESCRIPTIVES VARIABLES=Total#ofcows Total#oflactatingcows Milkyieldatcalving
Milkyieldatdryingoff
  /STATISTICS=MEAN STDDEV MIN MAX.

UNIANOVA Milkyieldatdryingoff BY Productionsystem2 Breeds2 DryingoffPractice2
FarmsID
  /RANDOM=FarmsID
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /SAVE=PRED
  /PRINT DESCRIPTIVE
  /CRITERIA=ALPHA(.05)
  /DESIGN=Productionsystem2 Breeds2 DryingoffPractice2 Breeds2*Productionsystem2.

UNIANOVA Milkyieldatdryingoff BY Productionsystem2 Breeds2 DryingoffPractice2
FarmsID
  /RANDOM=FarmsID
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /SAVE=PRED
  /POSTHOC=Productionsystem2 Breeds2 DryingoffPractice2(TUKEY)
  /EMMEANS=TABLES(Productionsystem2) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(Breeds2) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(DryingoffPractice2) COMPARE ADJ(LSD)
  /PRINT DESCRIPTIVE
  /CRITERIA=ALPHA(.05)
  /DESIGN=Productionsystem2 Breeds2 DryingoffPractice2.

UNIANOVA Milkyieldatcalving BY Productionsystem2 Breeds2 DryingoffPractice2
FarmsID
  /RANDOM=FarmsID
```

```
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /SAVE=PRED
  /POSTHOC=Productionsystem2 Breeds2 DryingoffPractice2(TUKEY)
  /EMMEANS=TABLES(Productionsystem2) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(Breeds2) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(DryingoffPractice2) COMPARE ADJ(LSD)
  /PRINT DESCRIPTIVE
  /CRITERIA=ALPHA(.05)
  /DESIGN=Productionsystem2 Breeds2 DryingoffPractice2.

CROSSTABS
  /TABLES=Udderleakage BY DryingoffPractice2 Breeds2 Productionsystem2
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ CORR
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=Mastitis2 BY DryingoffPractice2 Breeds2 Productionsystem2
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ CORR
  /CELLS=COUNT
  /COUNT ROUND CELL.


UNIANOVA calvingtoinseminationlength BY Productionsystem2 Breeds2
DryingoffPractice2 FarmsID
  /RANDOM=FarmsID
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /SAVE=PRED
  /POSTHOC=Productionsystem2 Breeds2 DryingoffPractice2(TUKEY)
  /EMMEANS=TABLES(Productionsystem2) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(Breeds2) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(DryingoffPractice2) COMPARE ADJ(LSD)
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  /DESIGN=Productionsystem2 Breeds2 DryingoffPractice2.
```

Appendix C: Abstract of Publication

Animal and Veterinary Sciences
2024, Vol. 12, No. 5, pp. 128-137
https://doi.org/10.11648/j.avs.20241205.11

SciencePG
Science Publishing Group

Research Article

Association of Cow Drying off Practices with Milk Yield and Udder Health Outcomes in Peri-Urban Smallholder Dairy Herds

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Abstract

In peri-urban smallholder dairy herds, farmers face challenges in drying off cows due to a lack of evidence-based recommendations. This study examined the associations between cow drying-off practices, mean milk yield at drying off and during early successive lactation, and the odds of mastitis and udder leakage cases in herds around Nakuru city, Kenya. A cross-sectional survey of 232 cows across 172 herds was conducted. Mean milk yield was determined using a general linear model, while the odds ratios for mastitis and udder leakage were estimated using a binary logistic regression model, with drying-off practice, cow breed, and dairy management intensification as explanatory variables. All the three explanatory variables were significantly associated ($p<0.05$) with mean milk yield at drying off, early successive lactation, and the occurrence of mastitis and udder leakages. Cessation of milking (57.3%) was more common than abrupt cessation (42.7%). Mean milk yield was 2.6 liters/day at drying off and 13.4 liters/day during early successive lactation. Teat sealants were applied to cows producing more than 5 liters/day, while gradual reduction in milking, complete cessation of milking, or dry-cow therapy was used for cows producing less than 3 liters/day. During early successive lactation, cows dried off using teat sealant, salt application, stopping concentrate feeding, or gradual reduction in milking produced more milk (14 liters/day) than those dried off by abrupt cessation or dry-cow therapy (10-12 liters/day).Relative to abrupt cessation, the odds of mastitis and udder leakage were lower ($p<0.05$) with dry-cow therapy (odds ratio 0.12; 0.12), gradual cessation of milking (odds ratio 0.22; 0.29), or stopping concentrate feeding (odds ratio 0.14; 0.26). The study found that gradual reduction in milking (47%) and abrupt cessation of milking (22%) were the most common drying-off practices. These methods are effective for cows producing less than 3 liters/day at the start of drying off and do not result in milk loss during early successive lactation. However, abrupt cessation of milking is more likely to result in poor udder health outcomes. Though teat sealant was rarely used (3.9%), it proved effective for cows producing more than 5 liters/day, maintaining milk production and udder health during early successive lactation. These findings provide crucial insights for farmers on selecting appropriate drying-off practices to optimize milk yield and udder health.

Keywords

Smallholders, Dairy Intensification, Milk Production, Cow Welfare, Mastitis, Udder Leakages

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Received: 30 July 2024; **Accepted:** 24 August 2024; **Published:** 11 September 2024

Appendix D: Ethical Clearance.

EGERTON UNIVERSITY

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P. O. BOX 536
EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DIR/009
Approval No. EUISERC/APP/304/2024 *20th February 2024*

Landing Sonko
P.O. Box 536-20115
Egerton.
Telephone: +254 0716237464
E-mail: lansonko4@gmail.com

Dear Sonko,

RE: ETHICAL APPROVAL: CHARACTERISATION OF COW DRYING OFF MANAGEMENT STRATEGIES IN PERI-URBAN SMALLHOLDER DAIRY HERDS AROUND NAKURU COUNTY, KENYA

This is to inform you that the *Egerton University Institutional Scientific and Ethics Review Committee* has reviewed and approved your above research proposal. Your application approval number is *EUISERC/APP/304/2024*. The approval period is *20th February 2024 – 21st February, 2025*

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. You are required to adhere to the Institutional Experimental Animals Use and Care policy.
iii. All changes including (amendments, deviations, and violations) are submitted for review and approval by *Egerton University Institutional Scientific and Ethics Review Committee*.
iv. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to *Egerton University Institutional Scientific and Ethics Review Committee* within 72 hours of notification.
v. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to *Egerton University Institutional Scientific and Ethics Review Committee* within 72 hours.
vi. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

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vii. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
viii. Submission of an executive summary report within 90 days upon completion of the study to *Egerton University Institutional Scientific and Ethics Review Committee*.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely,

RESEARCH ETHICS
Date. 20/02/2024

Prof. Raphael M. Ngure
CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW CTTEE
RMN/BKO

Appendix E: Nacosti Clearance

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **998227** Date of Issue: **09/March/2024**

RESEARCH LICENSE

This is to Certify that Mr.. Landing Sonko of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nakuru on the topic: ASSESSMENT OF COW DRYING-OFF MANAGEMENT PRACTICES IN PERI-URBAN SMALLHOLDER DAIRY HERDS AROUND NAKURU CITY, KENYA for the period ending : 09/March/2025.

License No: **NACOSTI/P/24/33434**

998227

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

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See overleaf for conditions

Appendix F: Conference Presentation

15TH BIENNIAL INTERNATIONAL CONFERENCE

Levels of milk yield associated with different cow drying-off practices deployed by Nakuru peri-Urban smallholder dairy farmers

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Department of Animal Science, Egerton University
Corresponding Author: lansonko4@gmail.com

ABSTRACT

Production intensification in smallholder peri-urban dairy farms shows an inclination toward high-yielding cows but how they manage the drying-off period is a knowledge gap that this study aims to fill. Cow drying-off practices among high yielders can impact cow productivity, health, welfare and fertility in successive lactation if poorly implemented. This study was a cross-sectional observational survey of cows with successive lactations to establish the length of drying-off, drying-off practices and the levels of milk yield associated with different cow drying-off practices deployed on smallholder dairy farms around the Nakuru peri-urban. A total of 87 sample farms were visited of which 174 cows with successive lactations were examined. Of these 174 cows, the drying-off practices most frequently deployed were complete stopping of milking and gradual reduction of milking (each 30.5 %; 53/174). However, milk yield at the start of drying-off differed ($p<0.05$) with the drying-off practice, being 6.975 litres/day when complete stopping of milking and 4.042 litres/day when gradual reduction of milking was practised. Dry cow therapy was less practised (4.6%: 8/174) and milk yield averaged 6.625 litres/day. Cows that died off by 60 days before the calving date were more (64.9%: 113/174) than those dried off after 60 days (35.1%: 61/174). The results are relevant to the choice of appropriate cow drying-off management practices that optimize cow productivity and incomes in peri-urban smallholder dairy herds.

Keywords: Dairy, milk yield, peri-urban, smallholder farmers, Nakuru

15th Biennial International Conference Organized by Egerton University. Conference Day one: Tuesday 19th March 2024. Venue: Lord Egerton Hall.