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Research Article

Common Peri Parturient Diseases, Disorders and Levels of Serum Nutritional Elements of One Humped Female Camel (*Camelus dromedaries*) in Northern Kenya

Florence Thiakunu[1, *], **James Kirimi**[2], **Joshua Arimi**[3]

[1]Department of Animal Science, Meru University of Science and Technology, Meru, Kenya
[2]Department of Livestock and Fisheries Development, Meru County Government, Meru, Kenya
[3]Department of Food Science, Meru University of Science and Technology, Meru, Kenya

Abstract

Camel rearing systems in the Arid and Semi Arid lands are undergoing significant changes, particularly around trading centers. More intensive camel production practices are replacing traditional extensive production systems. A cross-sectional study was conducted in Burat Ward, Isiolo County for intensive production systems and Laisamis, Marsabit County (extensive production systems). The aim of the study was to investigate the prevalence of common peri-parturient diseases and assess whether production systems and physiological status influence variations in serum levels of glucose, calcium, and magnesium. Data collection methods included focus group discussions, structured interviews, and blood sample analysis. The data were analyzed using descriptive statistics, mean comparisons, and Analysis of Variance. Results revealed that the prevalence of common diseases were higher in Laisamis (13.32-27%) than in Burat (4.59-12.06%). Likewise, gross mortality was higher in Laisamis (37.39%) than Burat (7.09%). Serum glucose levels were significantly lower in peri-parturient camels (3.91 and 4.45 mmol/L) compared to those in ordinary physiological status (6.09 mmol/L). Calcium levels remained consistent across physiological statuses and production systems (10.62-11.39 mg/dl). Magnesium levels were similar across physiological statuses but varied depending on the production system, they were higher in Burat (2.91-3.08 mg/dl) than Laisamis (2.46-2.71mg/dl). Most of the camels had below, normal and above normal levels of serum glucose, calcium and magnesium respectively. This was an indication that magnesium levels are influenced by dietary availability rather than physiological status. Malnutrition was the leading cause of death around parturition, primarily driven by negative energy balance. Blood glucose levels were found to depend on the physiological status of the camel, while calcium levels are tightly regulated by homeostatic mechanisms. Magnesium levels, however, depend on dietary intake. The study recommends improving camel nutrition during late pregnancy and early lactation to reduce the risk of metabolic and nutritional disorders.

Keywords

Peri Parturient, Production System, Diseases, Disorders, Glucose, Magnesium, Calcium

[*]Corresponding author: karimithiakunu@gmail.com (Florence Thiakunu)

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1. Introduction

Livestock production forms an integral part of agriculture. In the arid and semi-arid areas (ASALs) it is only animals that can utilize the scarce natural resources where rainfall is unreliable for crop production. In Kenya for example ASALs form 80 % of the landmass and 50% of the livestock herd including 4.6 million camels [1]. Due to the high demand for animal protein and change of feeding habits it is anticipated that the next agricultural revolution will be a Livestock development [2]. It is expected that most of the animal products will come from Africa and Asia. Indeed, the world is undergoing a *livestock revolution* which is demand driven [3]. Pastoralists in the ASALs have adopted various strategies to cope with the impacts of climate change, including transitioning from cattle to camels [4-6]. Camels hold significant potential to address food insecurity and drive economic growth.

Changes are taking place near towns such that camel farmers are intensifying their production and making some economic gains through sale of camel milk. This has been the case in Somali region of Ethiopia and Sudan [7]. In Kenya, this scenario has been observed in peri-urban areas of Isiolo town, attributed to increased demand for camel milk in Nairobi and other urban areas. With intensification, camel feeding styles have changed and may predispose camels to metabolic and nutritional disorders [8]. The disorders are due to poor regulation of calcium, magnesium and glucose which are nutritious components in camel milk. The normal glucose levels in camels are 6.86-8.08 mmol/L while calcium and magnesium are 8.48-12.5 and 2.07-2.25 mg/dl respectively [9]. The production and the reproductive performance of livestock depend on the health status at around the time of parturition [10]. In cattle it is documented that there is always the subclinical state of low levels of glucose and calcium which occurs at that stage [11] but little is known regarding camels.

Camels are seasonal breeders with breeding occurring shortly after the rains when feeds are plenty. Gestation is 360-420 days hence calving interval is long. There is some knowledge on the infectious camel diseases while metabolic disorders are poorly documented. Retained placenta, uterine prolapse and dystocia have also been reported [12]. Parturient udder edema before and after parturition has been reported in the highly producing camels in Pakistan [13]. Agalactia especially in very young heifers in the first lactation and cases of milk fever in camels that are poorly supplemented with the minerals has been reported in Ethiopia [14]. In African countries including Kenya, camel abortion has a high incidence causing a notable economic loss [15].

With the camel production systems becoming sedentary, information on the likely prevalence of metabolic and nutritional disorders is scanty. It is not known if the levels of glucose, calcium and magnesium reduce at peri-parturient stage as is the case with bovine. The objectives in this study therefore were to determine the clinical prevalence of the peri-parturient diseases and compare morbidities and mortalities in intensive and extensive production systems. Furthermore, glucose, calcium and magnesium levels before, after parturition and in the normal physiological statuses were compared in the two production systems. Information generated will benefit the stakeholders in camel industry including the service providers and the policy makers who have a responsibility of promoting camel commercialization. Animal health workers will acquire knowledge on the new health conditions which might come along with camel intensification.

2. Materials and Methods

2.1. Study Area

The study was carried out in two wards i.e Burat in Isiolo County and Laisamis in Marsabit (Figure 1). Burat pastoralists practice the peri-urban intensive production system while in Laisamis keep camels in extensive production system. This was conducted in the month of April, 2023 during the calving season. There was no constituted feed ration but camels had access to nutritious shrubs and water was in plenty in the two wards. The camel keeping households formed the sampling units. Blood analysis was performed at Kericho Regional Veterinary Investigation Laboratories (RVILs).

The two wards, Burat in Isiolo and Laisamis in Marsabit were purposively sampled due to their intensive and extensive production practices, respectively. Burat ward in the peri urban areas of Isiolo town and Laisamis in rural Marsabit county and both had a total of 526 households keeping camels [1].

2.2. Research Design

The research design was cross sectional relying on recall data about animals that suffered common peri-parturient diseases during the calving season prior to the research. This period spanned from November 2022 to April 2023. The levels of glucose, calcium, and magnesium were analyzed in normal physiological status, as well as late gestation and early lactation.

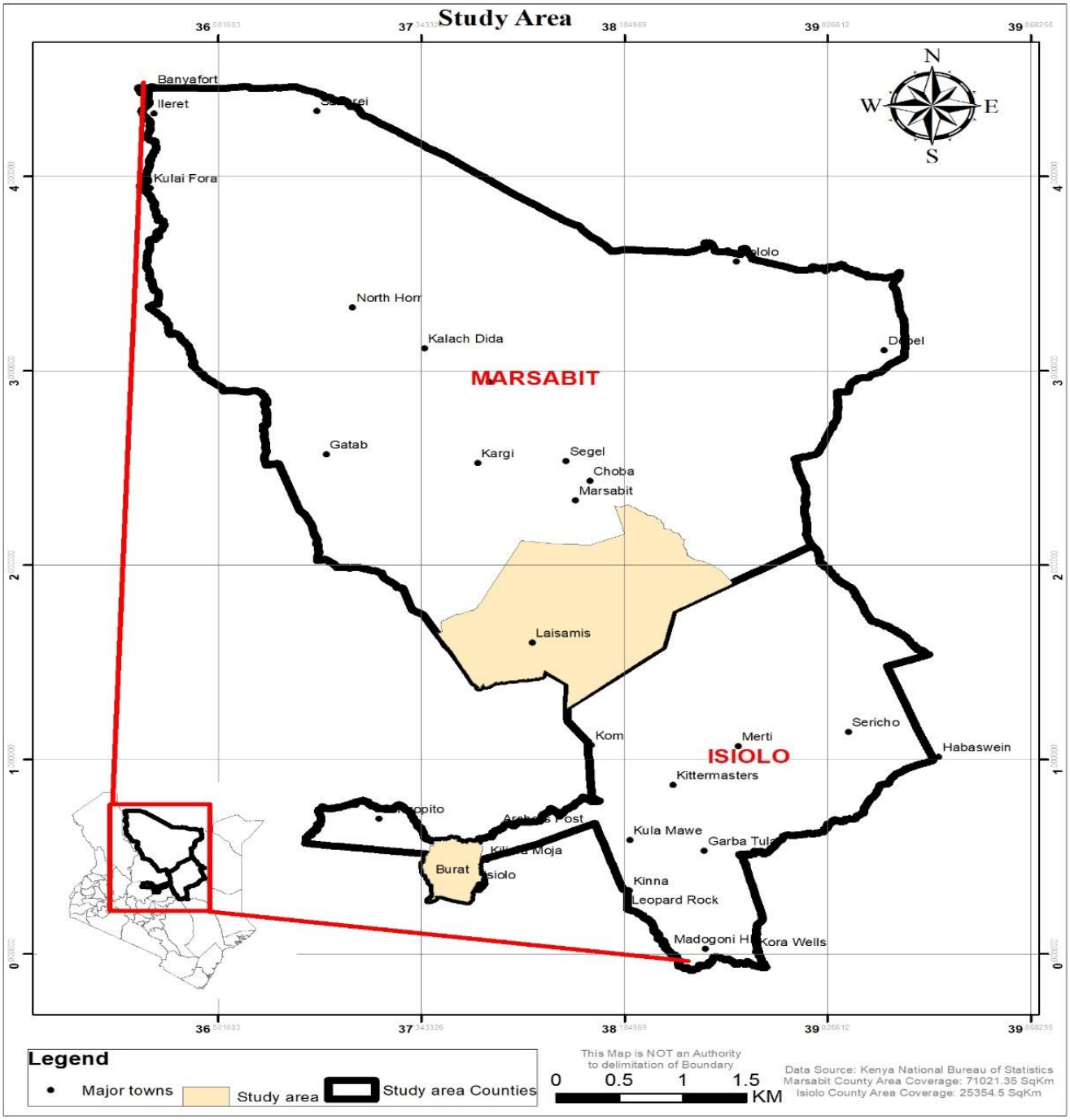

Figure 1. *Map of Isiolo and Marsabit counties showing Burat and Laisammis wards [1].*

2.3. Sample Size

Sample size was calculated using the formula [16].

$$n'=1\div(1/n+1/N) \quad (1)$$

Where:
n'=sample size for finite population.
n=sample size for infinite population=384
N=population size=526

hence the sample size was n'=1÷ (1/384+1/526) =222 households

2.4. Sampling Design

A two-stage sampling method was applied. The first stage purposively sampled Burat and Laisamis wards in Isiolo and Marsabit Counties, respectively. The second stage conveniently sampled households willing to participate.

2.5. Data Collection

Two Focus Group Discussions of 14 participants each including livestock staff, Community Disease Reporters, herders were conducted. Scheduled interviews were administered by CDRs in local languages to 218 households using a questionnaire uploaded in Kobocollect [17]. Samples for nutritional elements analysis were collected from 33 camels from the three physiological status in each ward. Five (5 mls) of blood was drawn from jugular vein using aseptic technique and emptied into a plain vacutainer with a clot activator. The three categories were late pregnancy (one month before calving), early lactation (less than one month after calving) and ordinary meaning not recently calved and not pregnant.

2.6. Laboratory Analysis

Serum was separated using TGL-16M benchtop centrifuge at 2,000 rpm for 10 minutes and transferred to a test tube. It was analyzed for glucose, calcium and magnesium levels using spectrophotometry as described by Renjini and Dileep [18] using a Beckman Spectrophotometer. A blood sample with glucose levels below 6.86 mmol/L, calcium below 8.48 mg/dL, or magnesium below 2.07 mg/dL indicated either subclinical or clinical deficiency.

2.7. Statistical Analysis

Focus Group Discussions information was analysed by verbal interactions, identifying recurring themes. Data were uploaded in Microsoft excel worksheet and later transferred to SPSS Version 25. Frequency counts and percentages were performed by comparing the diseases profiles and the frequencies of disease prevalence in the two rearing systems. ANOVA was used in comparing the means of the glucose, calcium and magnesium levels in the serum for the three different physiological statuses, expressed as at p=0.05 significance.

3. Results

3.1. Prevalence of Peri-parturient Diseases

The Focus Group Discussions listed the common camel diseases which occur at around the time of parturition. These included recumbence which occurs at that time and was interpreted to be malnutrition due to negative energy balance. Abortion was interpreted to be either brucellosis or any other infection which is sexually transmitted. Prevalence of all diseases especially abortions, dystocia and retained after birth were more in the extensive system than the intensive (Table 1).

Table 1. *Peri parturient disease prevalence in Burat and Laisamis.*

Locations		**Burat (n=108)**		**Laisamis (n=110)**		**Total (n=218)**	
Number and Percentage		**No.**	**%**	**No.**	**%**	**No.**	**%**
Abortion	Yes	17	15.7	83	75.5	100	45.7
	No	91	84.3	27	24.5	118	54.3
Dystocia	Yes	26	24.1	48	43.6	74	33.8
	No	82	75.9	62	56.4	144	66.2
Retained placenta	Yes	23	21.3	57	51.8	80	36.5
	No	85	78.7	53	48.2	138	63.5
Downer camel	Yes	28	25.9	43	39.1	72	32.9
	No	80	74.1	67	60.9	146	67.1
Agalactia	Yes	29	26.9	44	40	74	33.8
	No	79	73.1	66	60	144	66.2
Mastitis	Yes	53	49.1	62	56.4	115	53
	No	55	50.9	48	43.6	103	47

3.2. Disease Mortalities and Morbidities

Mean disease morbidities were more in Laisamis ranging from 13.32% (malnutrition/recumbent female camel) to abortion (27%) than Burat ($p<0.05$) ranging from 4.59% (abortion) to 12.06% (mastitis). Differences in disease morbidities were all significant ($p<0.05$) except mastitis which was more at 0.1

significance level. All mean disease gross mortalities were more in Laisamis than Burat ($p<0.01$). Malnutrition was the highest contributor to mortality in Burat and the second highest contributor in Laisamis after abortions. (Table 2).

Table 2. *Disease morbidities and mortalities.*

	Burat	Laisamis	p/value
Disease Morbidities			
Abortion (n=80)	4.59 ±1.29	27.00 ±2.92	0.000
Dystocia (n=91)	6.90 ±1.44	13.40 ±2.29	0.020
Retained placenta (n=91)	6.00 ±1.51	16.38 ±2.46	0.000
Malnutrition/Downer (n=90)	6.96 ±1.24	13.32 ±2.42	0.017
Agalactia (n=90)	6.78 ±1.33	14.10 ±2.47	0.012
Mastitis (n=87)	12.06 ±1.63	16.64 ±2.30	0.099
Disease Mortalities			
Abortion (n=103)	0.00 ±0.00	12.37 ±2.13	0.000
Dystocia (n=102)	1.80 ±0.59	9.89 ±1.99	0.000
Retained placenta (n=102)	1.18 ±0.48	9.93 ±1.96	0.000
Malnutrition/Downer (n=103)	3.98 ±0.81	10.74 ±2.05	0.003
Agalactia (n=84)	0.55 ±0.39	8.04 ±2.18	0.001
Mastitis (n=103)	0.12 ±0.12	8.76 ±1.89	0.000
Percentage of dead to surviving	7.63%	59.73	
Gross mortality	7.09%	37.39%	

3.3. Serum Levels of Nutritional Elements

During the peri-parturient stage, a significant proportion of camels in Burat (97%) exhibited glucose levels below the normal range, compared to 63.6% during the ordinary stage. No glucose was detected in camels from Laisamis. Most camels (66.3% to 100%) had calcium levels within the normal range, while a majority (75.8% to 93.9%) showed above-normal magnesium levels across all physiological status. There was 3% level of magnesium deficiency in early lactation in Laisamis (Table 3).

Table 3. *Percentage of camels at different serum nutritional elements' levels.*

Serum nutritional elements level	Physiological state and the wards					
	Late pregnancy		Early lactation		Ordinary	
	Burat	Laisamis	Burat	Laisamis	Burat	Laisamis
Glucose						
Below normal	97		97	ND	63.6	
Normal	3		3	ND	27.3	
Above normal				ND	9.1	
Calcium						

Serum nutritional elements level	Physiological state and the wards					
	Late pregnancy		Early lactation		Ordinary	
	Burat	Laisamis	Burat	Laisamis	Burat	Laisamis
Below normal						6.1
Normal	90.9	100	87.9	81.8	100	66.3
Above normal	9		12.1	18		27.6
Magnesium						
Below normal	0			3		3
Normal	6.1	9.1	9.1	6	18.2	21.2
Above normal	93.9	90.9	90.9	91	81.8	75.8

Mean glucose levels in camels in Burat Ward across all physiological statuses ranged from 3.91 to 6.09 mmol/L, with significantly lower levels observed pre- and post-parturition compared to camels in ordinary physiological status ($p<0.05$). In Laisamis, glucose levels were undetectable across all statuses. Calcium levels were consistent across all physiological categories in both wards, ranging from 10.62 to 11.39 mg/dL. Magnesium levels were higher in Burat (2.91–3.08 mg/dL) compared to Laisamis (2.46–2.71 mg/dL), showing regional differences but remaining consistent across physiological statuses within each ward (Table 4).

Table 4. *Serum nutritional levels across physiological statuses.*

Ward	Status	Glucose mmol/L	Calcium mg/dl	Magnesium mg/dl
Burat	Late pregnancy (n=33)	3.91 ± 1.44^{a}	10.76 ± 1.15^{ab}	2.95 ± 0.53^{ab}
	Early lactation (n=33)	4.45 ± 1.20^{a}	10.78 ± 1.32^{ab}	2.91 ± 0.53^{ab}
	Ordinary status (n=33)	6.09 ± 1.79^{b}	10.62 ± 1.24^{b}	3.08 ± 0.60^{ab}
Laisamis	Late pregnancy (n=33)	ND	10.75 ± 1.15^{ab}	2.57 ± 0.36^{cde}
	Early lactation (n=33)	ND	11.39 ± 1.16^{a}	2.71 ± 0.43^{bcd}
	Ordinary status (n=33)	ND	11.34 ± 2.18^{a}	2.46 ± 0.27^{ce}

Values are expressed as mean ± SD and $^{a, b, c, d, e}$ values in the same column having different superscript letters are significantly different ($p<0.05$).
ND: means not detected

4. Discussion

4.1. Prevalence, Morbidities and Mortalities of Peri-parturient Diseases

Peri parturient period in camel is the period four weeks pre-and post-partum characterized by changes in endocrine status of the animal, to provide for parturition and lactogenesis. It is also characterized by changes in tissue metabolism, nutrient utilization, and disruption in functioning of the immune system [19, 20]. In the present study, prevalence, morbidities and mortalities for most peri-parturient diseases were all higher in Laisamis than Burat. This indicates poor disease control measures in Laisamis under the extensive production system. Mortalities and morbidities were significantly higher in Laisamis than Burat could be due to poor immunity as a result of poor nutrition [21].

A study by Nagy [22] established the prevalence of abortion in camels beyond organogenesis (day 60 of gestation) was 5.05% which was consistent with the current study for

the peri urban production system in Burat. However, a higher rate was estimated in the current study for the extensive system which was 27%. This could be attributed to the fact that other studies relied on the sero-prevalence results for brucellosis which causes abortion [23].

The incidence of the retained foetal membranes is reported to be in the range of 2-11% in other studies by Nasr [13]. However, in the current study established that the prevalence was 6% for Burat and 16.4% for Laisamis. The causes of retained placenta may be predisposed by many factors which include infections, hormonal imbalances and nutritional deficiencies [24].

The difference in the level of clinical mastitis was less significant compared to the other peri-parturient diseases ($p=0.099$). It can be explained by the fact that in dairy industry animals giving high milk yields, were more vulnerable to host factors that were at a higher risk of mastitis than moderately yielding mammals [25]. Clinical mastitis, udder edema, failure of milk ejection due to hormonal imbalances and failure of myo-epithelial cells in the udder alveoli to respond to oxytocin can lead to agalactia [24].

The indicator of peri parturient malnutrition in the current study was the inability of the animal to rise up. Peri-parturient recumbence in camel can be a symptom of any terminal disease especially which is predisposed by trypanosomiasis [26]. Recumbence especially around parturition poses a lot of challenge in diagnosis and treatment because of the many differentials that have to be considered [27]. These include nutritional deficiencies for energy, protein and micronutrients associated with high nutritional demand. Furthermore, the female animals are susceptible to other diseases such as mastitis and pyometra at that time. Therefore, making an accurate prognosis is as important as making the right diagnosis [28].

The prevalence of dystocia in the intensive and extensive production system was 6.9% and 13.4% respectively. This contrasted with other studies such that in Saudi Arabia it was higher in the intensive (12.6%) than extensive (7.1%) [29]. The causes of dystocia are attributed to immaturity of the females, before first calving leading to failure of cervical dilatation and uterine inertia [30]. In this study this heifer maturity before first calving may have been achieved to some level in the peri-urban intensive production system than in the extensive production systems.

4.2. Serum Levels of Calcium, Glucose and Magnesium

In the present study, mean glucose levels in all statuses were lower than in other studies [31, 9]. Furthermore, the level of glucose in Laisamis ward was not detected. This was attributed to the long time taken to separate serum from blood [32]. Transporting blood to Kericho RVIL took more than 6 and 12 hours from Burat and Laisamis, respectively. Glucose levels in late pregnancy and early lactation were significantly less than in the ordinary status ($p<0.05$). This is an indication that camels were having subclinical hypoglycemia at around the time of parturition. It is attributed to the fact that there is mobilization of glucose towards fetal circulation in late pregnancy and it is also the only precursor for lactose synthesis in milk formation [33].

Calcium levels were almost the same in the two wards and in the three physiological status. This is an indication that camels were not destabilized in the calcium homeostasis during the peri parturient period and is consistent with other studies [34]. Calcium homeostasis in animals is tightly controlled through interaction of parathyroid, calcitonin hormones, and vitamin D. The sources are skeletal mobilization, intestinal absorption and elimination is through renal excretion [35].

Magnesium levels were higher than in other studies [36, 9]. There was a significant difference in the mean levels of magnesium between camels in Burat and Laisamis wards. However, the means for different physiological status in the same ward were equal. Magnesium homeostasis depends so much on gut absorption and renal excretion [37]. Unlike calcium homeostasis, shortage in dietary intake cannot be compensated from skeletal mobilization [38]. It means therefore that camels in Burat, Isiolo were accessing plants with higher levels of magnesium than the camels in Laisamis, Marsabit and was not dependent on the physiological status [39, 40].

5. Conclusion and Recommendations

Prevalence, morbidity and mortality of all peri parturient diseases were more in Laisamis than Burat. The significantly low peri parturient glucose levels predispose to poor health and production. Camels in Burat ward were accessing diets with higher levels of magnesium than the camels in Laisamis ward. Mineral supplementation is critical for milk production and camel health. There is need to improve management practices and do prompt treatment of dystocia, retained foetal membranes and mastitis. Further, proper planning to improve feeding in late pregnancy and early lactation including mineral supplementation is necessary in the diet all the time.

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Author Contributions

Florence Thiakunu: Conceptualization, data collection administration, investigation, methodology, data coding, writing original draft.

James Kirimi: Cross checking the drafts write-ups and proof reading final document

Joshua Arimi: Funding acquisition, data collection and analysis, referencing.

Conflicts of Interest

The authors declare no conflicts of interest.

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