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Effects of concentrate supplementation on lactating Dromedary Camels during mating season in Isiolo, Kenya

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ABSTRACT

Camels are resilient and have a high potential to contribute to food security and economic development in arid areas. However, this potential is being limited by diminishing feed resources due to the effects of climate change. Further, there is an upcoming peri-urban camel production system where the animals are limited in their movement. Consequently, camels do not get enough browse forages in terms of biomass and quality to meet their nutritional requirement. This has resulted in decreased production and reproductive performance. The objective of this study was to determine the effect of concentrate supplementation on lactating camels on productive and reproductive performance during mating season. A diet containing 16.80% crude protein (CP) and a digestible energy of 8.44 MJ/Kg was formulated and supplemented in the evenings with a group of ten camels. Another group of 10 camels acted as the control. Milking was done in the morning and production from each camel was recorded in liters. Percentage milk fat and protein analysis were done weekly using Gerber and Kjeldahl methods respectively. Serum biochemical levels were determined using spectrophotometry in the fourth week. Confirmation of pregnancy was done on the 5th month after mating by chemiluminescent progesterone assay. Camels were then divided into four groups. These were, supplemented pregnant(4) supplemented and not pregnant(6) un-supplemented pregnant(1), and un-supplemented and not pregnant(9). Paired mean comparisons were done to ascertain differences within the four groups. Mean daily milk production was 25.26±0.42 and 22.79±0.41 liters for supplemented and un-supplemented groups respectively ($p<0.001$). Paired mean differences were highest between pregnant supplemented and pregnant un-supplemented pair ($p=0.165$). Biochemical profiles, mean milk protein and fat percentages were significantly higher for supplemented than un-supplemented (p 0.05). All supplemented camels were mated within the first two weeks and had a higher conception rate (40%) than un-supplemented (10%). The study recommends concentrate supplementation during mating season to improve fertility and milk production, especially in pregnant camels.

Introduction

Camels belong to the Camelidae family and are classified into large camels (Camelus dromedaries and Camelus bactrian) and small camels (Lama and Alpaca species). The world camel population is estimated to be 30 million with 80% in African, Arid, and semi-arid lands (ASALs) (Faye, 2015). ASALs which constitute 40% of the world land-

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mass and 80% of the Kenyan landmass (Government of Kenya, 2012) are better utilized through livestock rearing than any other form of production. Camels survive and produce milk in areas where vegetation is scarce. Initially, their use was for transporting baggage, a scenario that has since changed and is now used for food security and economic growth (Khan et al., 2003; Yam & Khomeini, 2015). The residents of the peri-urban areas of Isiolo are doing commercial camel milk production (Tadesse et al., 2014). They are adopting mainly the Somali type of camel which is heavier and more productive compared to other camel types. In this area, the camel milk trade is the most important source of household income with a monthly turnover of 88,167 US$ from milk sales (Mwaura et al., 2015).

Due to the effects of climate change, rainfall has been erratic over the years leading to scarcity of nutritious shrubs. Therefore, camels are not able to meet their nutritional needs for physiological body activities. Camels mate for a very short period not exceeding 90 days occurring when the climate is cool accompanied by enough browse (Khan et al., 2003). This means that with the effects of climate change the breeding seasons will also be erratic which can hurt herd growth. Resource allocation theory in animal production states that animals' genetic potential in terms of production and other physiological needs can only be realized if the environment including nutrition is favorable (Rauw & Glazier, 2009). However, this potential does not depend on the environment alone but also on the anatomical and physiological status (Friggens & Waaij, 2008).

Elevating stocking rates in various animals, particularly in cattle, has been associated with heightened production and reproductive outcomes, contingent on concurrent supplementation (Vibart et al., 2012). The provision of supplements has shown positive effects on blood and rumen parameters, as well as enhancing milk output and overall productivity in livestock (Saleh et al., 2023). Notably, supplementing camels during late pregnancy and early postpartum stages has been identified as a strategy to mitigate desertification. This supplementation approach demonstrates improvements in milk yield, composition, and reproductive performance (Mostafa et al., 2016; Moges, et al., 2016). These findings underscore the broader impact of strategic supplementation practices on diverse aspects of animal health and productivity.

Camels can be mated soon after parturition so long as their nutritional state is good which can reduce calving interval. In dairy cattle, milk production is reduced in the last trimester of gestation due to the rapid rate of fetal growth (Roche, 2003; De Vries, 2006). In camels, there is a significant drop in milk production of 38% in the ninth week for the pregnant and 14% for the non-pregnant camels(Nagy et al., 2015). Furthermore, there is a sudden drop in milk production on day 35 after conception in pastoral extensive production systems. Information on whether the same scenario is observed in the case of feed supplementation with a well-balanced feed ration is not adequate. It is not certain whether environmental factors are responsible for a significant drop in milk production in early pregnancy. The objectives of this study, therefore, were to determine the effect of concentrate supplementation on lactating camels on performance and serum biochemical levels in the mating season.

Materials and Methods

Study site

The study was conducted at the Research Centre of Ewaso Ng'iro North Development Authority in Ngaremara ward, Isiolo County, at coordinates Latitude $0^0$21'20.29" N and Longitude $37^0$34'59.90" E. Proximate analysis of feed ingredients and ration happened at the animal nutrition labs of Nairobi and Chuka Universities. Kericho Regional Veterinary Investigation Laboratories performed serum analysis for protein, glucose, and minerals. Lancet Laboratories in Nairobi handled progesterone hormone analysis, while Meru University of Science and Technology's food science labs analyzed milk's protein and fat content.

Ingredients	Amount (Kgs)	Ratio (%)	DM (%)	CP (%)	DE(MJ/Kg)
Maize germ	20.00	15.33	13.79	2.45	1.84
Maize grain	11.00	8.43	7.57	0.84	1.20
Wheat bran	8.00	6.13	5.52	0.86	0.62
CSC	7.00	5.36	4.89	1.61	0.46
Sunflower cake	20.00	15.33	13.79	3.83	1.46
Acacia pods	10.00	7.66	6.90	1.53	0.73
Rhodes Grass	40.00	30.65	26.05	2.45	2.15
Molasses	10.00	7.66	6.13	0.00	NA
Urea	1.50	1.15	1.03	3.22	NA
DCP	1.00	0.77	0.75	0.00	0.00
Limestone	1.50	1.15	1.13	0.00	0.00
Salt	0.50	0.38	0.33	0.00	0.00
Grand total	**130.50**	**100.00**	**87.88**	**16.80**	**8.44**

Table 1: *Ingredients and calculated chemical composition of camel supplement*

Feed ration preparation

The feed was formulated to meet the nutrient requirement of dairy cattle (National Research Council, 2021). A feed supplement containing 16.8% CP and 8.44 MJ/Kg digestible energy was formulated using ingredients shown in Table 1. The feeding ingredients were balanced using Excel software. The ingredients were sourced from local market feed dealers in Meru and Isiolo Counties. Rhodes grass was shredded and packed in gunny bags separately while the dry grain ingredients were crushed using a hammer mill and later mixed evenly together with salt and limestone. Molasses and urea mixture were constituted daily for every individual camel to avoid chances of urea toxicity(Faye et al., 2018). A total of 2,500 kgs was constituted in bulk since ten camels consumed 35 kgs of the ration per day for 70 days.

Feeding experiment

The experiment was conducted in January, February, and March 2022 using twenty camels in their 2-6 parities and less than three months after calving. The after-only with control experimental design(Kothari, 2004) was used because it was challenging to have pre-treatment measurements. The camels were divided into 2 groups and one group was supplemented while the other group acted as the control. All camels browsed for six hours in January and February and hours were adjusted to eight in March after the onset of dry season. One group was supplemented with 3.5 kgs of formulated ration after the day's browse. Constituting 3.5 kgs per camel was done by mixing 2 kg of grain mixture with 1 kg of Rhodes grass in every feeding trough. Then 3 kg of molasses and 300g of urea were mixed with 20 litres of water. Supplement for one camel was made by adding two liters of molasses urea mixture to every feeding trough with ground grain and Rhodes grass and mixing thoroughly. Camels were allowed to graze along with their calves during the day and only separated in different enclosures at night.

Proximate feed analysis

Proximate analysis of feed ingredients and the ration involved the application of AOAC (1995) protocols. DM was ascertained by air-drying a measured sample in an oven at 105°C for 8 hours, followed by placement in a desiccator for cooling and subsequent re-weighing. The dry matter percentage is calculated based on the remaining weight. The Kjeldahl method was employed for determining crude protein content, involving digestion, distillation, and titration until the nitrogen content in the feed sample was established. Ash content was determined by subjecting a sample to a muffle furnace at 550°C for 4 hours, followed by desiccation in a crucible and reweighing. The increase in weight in the crucible represents the ash content. Ether extract (EE) determination was conducted through solvent extraction using a Soxhlet extractor. For crude fiber (CF) determination, a measured sample was mixed in sulfuric acid, boiled for 30 minutes,

Ingredients	Rhodes grass	Sunflower	Cotton seed meal	Acacia pods	Maize grain	Maize germ	Wheat bran	Mixed dry ration
Proximate composition%								
DM	89.67	91.18	90.59	86.98	88.54	87.95	88.01	88.87
CP	4.66	19.45	14.21	11.68	7.23	7.78	10.22	11.76
EE	1.03	16.67	12.91	1.07	3.69	8.86	6.79	7.93
ASH	6.27	4.64	10.52	7.47	0.94	2.47	4.40	5.07
NFE	39.52	17.88	28.12	47.03	74.17	63.44	57.07	47.95
CF	38.19	38.54	24.84	19.73	2.51	5.42	9.53	16.76
NDF	74.03	58.06	49.28	29.61	8.73	33.77	40.52	36.66
ADF	42.15	36.84	36.05	19.60	1.05	5.31	7.05	17.65
ADL	8.99	13.54	11.40	6.33	0.70	1.75	0.75	5.74
Estimated ME (kcal/kg)	1676.51	2877.13	2868.65	1853.56	2474.98	2752.77	2884.47	2897.30

Table 2: *Proximate composition (%) of feed ingredients and the supplement*

Abbreviations: DM, Dry Matter; CP, Crude Protein; EE, Ether Extract; NFE, Nitrogen Free Extract; CF, Crude Fiber; NDF, Neutral Detergent Fiber ; ADF, Acid Detergent Fiber; ADL, Acid Detergent Lignin

mixed with potassium hydroxide, boiled again for 30 minutes, and subsequently weighed after placement in a muffle furnace. The nitrogen-free extract was determined by subtracting moisture content, CP, EE, ash, and CF from 100. The methods of Van Soest et al. (1991) were followed for determining neutral detergent fiber and acid detergent fiber.

Serum Progesterone Analysis

Pregnancy diagnosis was done on seventeen camels by progesterone assay 5 months after the mating season. Two camels, (Afghor 1 and Kulamawe) repeated at the time of progesterone assay, and one (Frey 1) was not mated at all. This confirmed that they were not pregnant at the time of the experiment. A blood sample was drawn from a jugular vein into a vacutainer with a clot activator. It was centrifuged to separate the serum from the other blood components and analyzed for progesterone levels. This was done through electrochemiluminescent microparticle immunoassay as described by Deguchi et al., (2004) and Zaher et al.,(2017) using Abbott Alinity I Analyzer. This method converts the substrate to a reaction product that can emit light with a wider dynamic range of luminous intensity having a linear relationship with the concentration of the measured substrate in mmol/L. The progesterone levels range from 0- 2.73 nmol/L in the non-pregnant state with levels rising more than 7.4 nmol/L two days after a successful mating and this is maintained throughout the pregnancy dropping at the time of parturition. Any camel serum progesterone level more than 3.5 mmol/L is considered pregnant (Mostafa et al., 2016; Kamoun & Jemmali, 2014). Pregnancy testing aimed to classify camels into four groups depending on pregnancy status and supplementation status.

Monitoring Milk Production

Milking was done completely only in the morning after allowing the calf to suckle a bit to stimulate the teats. Milk production per camel was recorded in liters for nine weeks and this was done before pregnancy confirmation. The production for the day was arrived at by multiplying the morning milking production by two because the most common frequency of milking camels is twice a day. After recording milk production, the herders were allowed to use milk for consumption and sale. However, milk samples were collected every week and pooled separately for the supplemented and un-supplemented camels. The sampled milk was hence transported the same day to the food science laboratories of Meru University of Science and Technology. The samples were preserved at a

Camel Name	Weeks									Progesterone levels(nmol/L)	Pregnancy Status
	1	2	3	4	5	6	7	8	9		
Supplemented camels											
Sumaya	*									26	Pregnant
Bordaga 3		*								0.6	Not- Pregnant
Dhugei 1	*									15.2	Pregnant
Dhugei 2	*									<0.6	Not- Pregnant
Pakistan	*									12.3	Pregnant
Frey 2	*									0.9	Not- Pregnant
Chongo	*									16.9	Pregnant
Afghor 2								*		1	Not- Pregnant
Bordaga 2		*								0.8	Not- Pregnant
Dhogonei	*			*						0.6	Not- Pregnant
Un-supplemented camels											
Walei	*									0.8	Not- Pregnant
Barduu 1	*				*					0.6	Not- Pregnant
Baryar 2							*			0.8	Not- Pregnant
Bordaga 1	*									1.1	Not- Pregnant
Dikidiki	*				*					1.2	Not- Pregnant
Barduu 2										0.9	Not- Pregnant
Baryar 1		*								11.9	Pregnant
Afghor 1	*					*					
Frey 1											
Kulamawe	*										

Table 3: *Camel reproductive parameters*

temperature of 40C and later analyzed for fat and protein composition.

Milk protein analysis

Protein content in milk was analyzed every week in triplicate using the Kjeldahl method which tests for the levels of nitrogen as described by Elkot et al., (2021). In this method, a nitrogen atom in the milk sample is converted to ammonia which is distilled from an alkaline medium and absorbed in boric acid. Ammonia is then determined by titration with mineral acid. This is with the assumption that the level of nitrogen in milk protein is 15.67%. Therefore, the percentage of protein in the milk is the amount of Nitrogen in the milk sample multiplied by 1÷15.67*100.

Milk fat analysis

Analysis of milk fat content was done every week in triplicate using the Gerber by weight method as described in Hadef et al., (2018) and Elkot et al., (2021). This is by mixing sulphuric acid with milk in a butyrometer then adding aso-amyl alcohol before thoroughly mixing and centrifugation to separate fat which is now straw yellow. The fat column is then brought to the graduation mark. The difference between the upper and lower scale readings corresponds to the lowest fat meniscus and surface of separation of fat and acid and is the percentage of fat content in the milk.

Serum Biochemical Analysis

Serum analysis was done for the biochemical nutritional elements such as glucose levels, total protein, calcium, phosphorous, and magnesium levels using spectrophotometry as described by Renjini and Dileep (2017). This is a method used to measure the concentration of solutes in a solution by checking the amount of light absorbed. Light absorbed then passes through a digital display meter that can record the weight of solute per a specific volume of the solution in mg/dL or mmol/liter. It was done using a Beckman Spectrophotometer.

Statistical analysis

Statistical analysis was done using SPSS Version 20. The mean comparisons for milk production; serum glucose, protein, albumen, calcium, phosphorus magnesium, fat, and protein percentage in the milk for the supplemented and unsupplemented camel were done for each pair. Paired sample tests were used to determine the differences among the four categories of camels based on pregnancy and supplementation. Means were expressed as Mean ± SE at p=0.05 confidence level

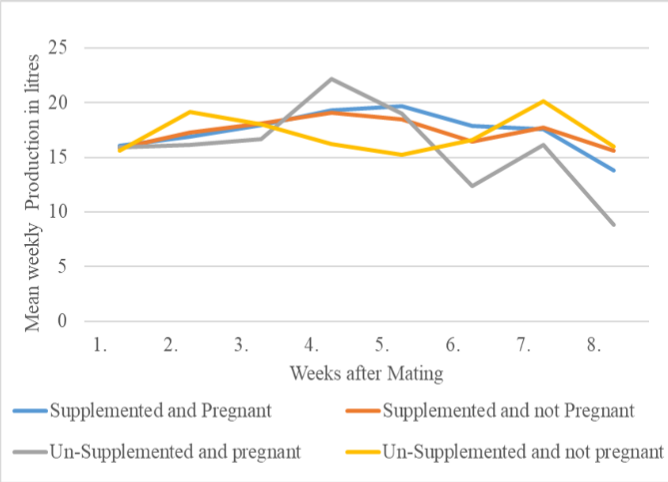

Figure 1: *Total daily milk production for the supplemented and un-supplemented group*

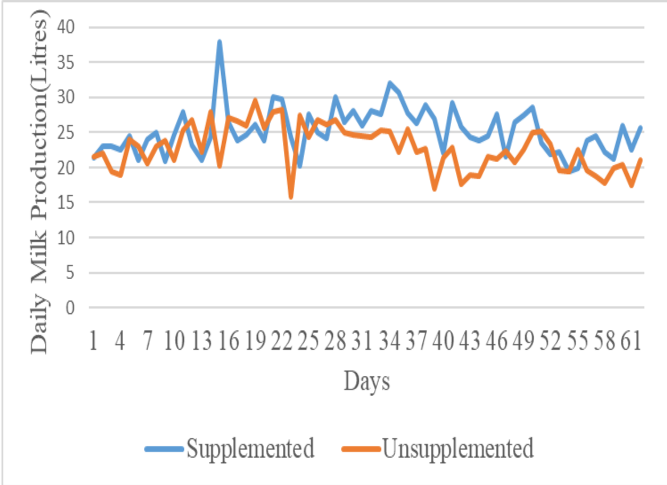

Figure 2: *Weekly milk production in the four-camel status*

Results

Ingredients and supplement proximate composition

Table 2 shows the proximate nutrient composition results of various feed ingredients. Sunflower meal exhibited the highest crude protein (CP) content at 19.45%, followed by cottonseed meal at 14.21% and acacia pods at 11.68%. Regarding metabolizable energy, wheat bran (2884 kcal/kg), sunflower (2877 kcal/kg), and cottonseed meal (2868 kcal/kg) recorded the highest values, while Rhodes grass (1676 kcal/kg) and acacia pods (1853 kcal/kg) had the lowest values. Maize grain (2474 kcal/kg) and maize germ (2752 kcal/kg) demonstrated moderate metabolizable energy. Rhodes grass hay displayed the highest levels of crude fiber (CF), neutral detergent fiber (NDF), and acid detergent fiber (ADF) at 38%, 74%, and 42%, respectively. In contrast, maize grain exhibited the lowest values for CF (2.51%), NDF (8.73%), and ADF (1.05%). These feed ingredients are required first for maintenance, production, and reproduction.

Weekly reproductive parameters

The results of reproductive parameters, serum progesterone levels, and pregnancy status are shown in Table 3. All except one of the supplemented camels were mated within the first 14 days of supplementation and one among mated repeated after 21 days. The remaining one was mated on the 8th week. In the un-supplemented camels, seven were mated in the first 14 days, two repeated in the 5th week, one in the 6th week, and one mated for the first time in the 7th week. Pregnancy confirmation indicated that four of the supplemented and one of the un-supplemented were pregnant at the end of the mating season. Therefore the conception rate for the supplemented and un-supplemented was 40% and 10% respectively.

Milk production

Figure 1 shows the daily milk production curves for the two groups for 63 days. Mean daily milk production for supplemented and un-supplemented groups of 10 camels were 25.26±0.42 and 22.79±0.41 liters respectively with a difference of 2.46± 0.52 liters ($p<0.001$).

Mean weekly milk production after mating was 17.38±0.66 and 17.32±0.44 liters for the supplemented pregnant and supplemented not pregnant respectively. Likewise, for un-supplemented camels, the weekly mean was 15.90±1.41 and 17.11±0.63 liters for the pregnant and not pregnant respectively. Figure 2 shows weekly lactation curves for four camel groups.

The paired mean comparison established there was no significant mean difference between the four groups. However, Table 4 shows the highest

Pairs	Status of Camels	Mean Difference	SE of Mean	t	Sig. (2-tailed)
1	Supplemented pregnant & supplemented not pregnant	.06	.35	.167	.872
2	Supplemented pregnant and un-supplemented pregnant	1.48	.95	1.551	.165
3	Supplemented pregnant & un-supplemented not pregnant	.27	.91	.293	.778
4	Supplemented not pregnant & un-supplemented pregnant	1.42	1.06	1.342	.221
5	Supplemented not pregnant & un-supplemented not pregnant	.21	.70	.297	.775
6	Un-supplemented pregnant & un-supplemented not pregnant	-1.21	1.55	-.782	.460

Table 4: *Paired mean weekly comparison for the four camel groups*

difference of 1.48±0.95 liters between pregnant supplemented and pregnant un-supplemented (Pair 2) though not significant (p=0.165). The lowest is 0.06±0.35 in supplanted pregnant and supplemented not pregnant (Pair 1) and is not significant (p=0.872).

Milk protein content

Milk protein content for the un-supplemented camels was ranging from 4.98±0.13% to 5.03±0.03%. There was a significant difference in the supplemented starting immediately after the onset of supplementation. The levels of percentage protein increased every week as the camels continued feeding on the supplemented diet ranging from 5.03±0.00 % in the second week to 5.39±0.13 % in the 9th week (table 5).

Milk fat content

Milk fat content for the un-supplemented camels ranged from 3.07±0.07% to 3.37±0.06%. The supplemented camels' milk was higher in percentage fat than the un-supplemented. The difference in the percentage of fat in the milk was significant in the third week (p 0.05) and was not significant in the 6th week (p 0.05). Table 6 shows the weekly percentage of fat in the supplemented and un-

Weeks	Supplemented	Control	p- Value
2	5.03 a ±0.00	5.02b ±0.02	0.00
3	5.07 a ±0.13	5.01 b ±0.03	0.00
4	5.17 a ±0.34	5.03 b ±0.03	0.00
5	5.20 a ±0.18	5.02 b ±0.00	0.00
6	5.24 a ±0.13	5.02 b ±0.03	0.00
7	5.35 a ±0.21	4.99 b ±0.01	0.00
8	5.33 a ±0.13	4.98 b ±0.13	0.00
9	5.39 a ±0.13	5.02 b ±0.19	0.00

Table 5: *Paired mean weekly comparison for the four camel groups*

Values are expressed as mean ± SE. a, b, values in the same row having different superscript letters are significantly different (p<0.05).

Weeks	Supplemented	Control	p -Value
2	3.42±0.09	3.37±0.06	0.090
3	3.37^{a} ±0.03	3.07^{b} ±0.07	0.018
4	3.53^{a} ±0.18	3.10^{b} ±0.00	0.001
5	3.50^{a} ±0.58	3.13^{b} ±0.09	0.005
6	3.37±0.09	3.20±0.10	0.180
7	3.57^{a} ±0.03	3.10^{b} ±0.06	0.000
8	3.43^{a} ±0.09	3.13^{b} ±0.33	0.018
9	3.53^{a} ±0.18	3.13^{b} ±0.09	0.002

Table 6: Weekly mean milk fat percentage (n=3)

Values are expressed as mean ± SE. a, b, values in the same row having different superscript letters are significantly different (p<0.05)

Serum Biochemical elements	Supplemented	Un-supplemented	p-Value
Glucose (mmol/l)	7.80±0.61	6.00±1.01	0.065
Total Protein (g/dl)	5.91^{a}±0.20	5.33^{b}±0.14	0.016
Serum Albumin (g/dl)	3.12±0.35	2.50±0.03	0.176
Phosphorus (mg/dl)	11.97^{a}±0.31	9.17^{b}±1.01	0.040
Magnesium (mg/dl)	5.16±0.29	4.84±0.25	0.480
Calcium (mg/dl)	15.75±0.20	16.37±0.72	0.438

Table 7: *Serum biochemical elements mean differences in the blood of the supplemented and un-supplemented camels(n=10).* Values are expressed as mean ± SE. a, b, values in the same row having different superscript letters are significantly different (p<0.05)

supplemented camels and the difference was maintained.

Serum biochemical profiles

Serum biochemical profiles are shown in Table 7. The average total protein levels were 5.91±0.20 g/dl for supplemented and 5.33±0.14 g/dl for un-supplemented, showing no significant difference (p>0.05). Phosphorus levels were significantly different at 11.97±0.31 mg/dl (supplemented) and 9.17±1.01 mg/dl (un-supplemented) with p 0.05. Glucose levels in mmol/L were 7.8±0.61 (supplemented) and 6.00±1.01 (un-supplemented), with a significant difference (p 0.1). Serum albumin and magnesium were higher in supplemented camels, while calcium levels were lower, though these differences were not significant (p>0.05).

Discussion

Ingredients and supplement proximate composition

Camels are pseudo ruminants, with the stomach having three compartments each with both glandular and non-glandular sections to enhance nutrient utilization efficiency. In the present study, the proximate composition of most ingredients fell below the established ranges observed in other studies. For example, sunflower exhibited 91.18%, 19.45%, 16.67%, and 4.64% of dry matter (DM), crude protein (CP), ether extract (EE), and ash, respectively, whereas Kirimi et al. (2021) reported higher values of 94.42%, 24.18%, 13.31%, and 5.08% for the same components. Similarly, the proximate composition of maize germ was at the lower limit compared to the findings of Noor (2013), with values for crude protein (7.78 vs. 9.45), crude fiber (5.42 vs. 10.46), neutral detergent fiber (NDF) (33.77 vs. 40.6), and acid detergent fiber (ADF) (5.31 vs. 8.8). The metabolizable energy for the mixed dry ration was slightly higher at 2,897.30 kcal/kg compared to the diet used by Moges et al. (2016) for camel supplementation(2,676.8 kcal/kg). Notably, the diet did not include Rhodes grass, which exhibited a lower metabolizable energy of 1,676.51 kcal/kg.

It is worth noting that although sunflower meal and cotton seed cake are classified as protein feedstuffs, their protein content was markedly low i.e. 19.45% and 14.21% respectively. This was probably due adulteration of ingredients by unscrupulous dealers (Kirimi, et.al, 2021). CP content in acacia pods (11.68%) and maize germ (7.78%) were extremely low compared with the findings of Noor (2013) of 17.45% and 9.46 % respectively. These differences can be explained by the fact that levels of the proximate composition of grains vary depending on the place where the grains were produced, the method of processing, and the level of infestation of grain with insect pests (Osipitan et al., 2012). The CP for mixed dry ration was low (11.76%) because urea and Rhodes grass were not included. Urea has a high level of Nitrogen and the CP in Rhodes grass is 11.18% (Ondabu et al., 2008). Protein content is essential to provide the necessary amino acids for tissue growth, as well as to support the development of microorganisms involved in microbial fermentation(Qureshi & Al-Ani, 2008).

Milk production

The difference in the mean daily milk production for 10 camels between supplemented and un-supplemented camels was 2.46±0.52 liters (10.79%). It is not consistent with other studies (Bakheit et al., 2015; Noor, 2013). This is because parameters that are important for milk production such as energy, CP, and digestibility are better in the wet than in the dry season (Noor, 2013) and were available to the experimental and control groups. It is possible that the un-supplemented camels were feeding on more shrubs compared to the supplemented camels. This is because when herbivores consume concentrate feeds, their nutritional needs can be fulfilled, eliminating the necessity of ingesting roughage. Indeed animals that are fed on a combination of roughage and concentrate ruminate during the day while those fed on roughage alone spend more time feeding during the day and ruminate at night (Moyo et al., 2019).

Low percentage levels of CP in the ingredients used in the supplemented feeds compared to other studies can explain the negligible difference in the mean daily milk production between supplemented and un-supplemented. Furthermore, the study was done during mating season and camels were restless and not feeding well. The mean differences in the paired comparisons show that milk reduction is influenced more by nutrition than pregnancy. This is consistent with other studies (Khan et al., 2003; Nagy et al., 2015). There is a trade-off between production and reproduction in the event of limited resources (Rauw & Glazier, 2009). The drop in the first trimester due to the effect of resource availability contrasts with other studies (Idris et al., 2015).

Milk protein and fat composition

The difference in milk protein levels increased linearly every week as the camels consumed the supplement diet. Urea, which was part of the constituents in the formulated ration causes an increase in the intake of the dry matter, crude protein, and the metabolizable energy and improves digestibility (Ntiranyibagira, et al., 2015). Further, the microorganisms utilize the non-protein nitrogen to synthesize amino acids for their growth. Other studies have indicated that the levels of ruminal ammonia nitrogen are directly proportional to the supplemented nonprotein nitrogen which in turn affects the microbial population growth (Wahyono et al., 2022). This further enhances the synthesis of fiber and synthesis of more protein which was found to be high in the serum and is also excreted in the milk. The use determines the levels of total protein in the milk and relies on the levels of Nitrogen in the milk. Furthermore, camel milk has been found to have higher levels of Urea compared to other herbivores which in the Kjeldahl method reflects as protein. (Farah, 1993).

High levels of fat in the supplemented camels were due to the improved supplemented diet which contained high fiber and urea in the ration. The addition of urea in the supplemented diet caused an increase in the ruminal pH favoring the growth of ruminal microorganisms which produce acetic acid and butyric acid. These are the main volatile fatty acids that are the main precursors of milk fat (Paengkoum et al., 2010).

Serum biochemical levels and conception rate

Levels of biochemical elements agree with Zaher et al., (2017) but were higher than what was established in other studies (Faye & Bengoumi, 2018; Elitok & Cirac 2018). This could be due to high levels of mineral content in the shrubs during the wet season. The conception rate is low, especially for the un-supplemented and this contrasts with other studies (Jaji et al., 2017). This is attributed to the pregnancy testing method of progesterone assay compared to cocking the tail method found to give false positives (Deen, 2008b). The low conception rate in un-supplemented camels is consistent with other studies that found fertility to be correlated to high levels of energy in the diet (Beam & Butler, 1997; Butler & Smith, 1989). Minerals form part of elements that constitute reproductive hormones explaining why reproductive parameters were improved with supplementation (Rodney et al., 2018).

Conclusions and Recommendations

Camel milk yields and quality were improved after intervention with a supplemented diet. Supplementation improves the reproductive indices at the time of mating and is therefore recommended. This should continue during the dry season which follows the mating season to avoid a sudden drop in milk production especially in the pregnant camels.

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Conflict of interest

The authors declare that they have no known conflicting interests in the work reported in this paper.

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