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Effects of Feeding Rumen Protected Methionine on Milk Production, Resistance to Mastitis and Cost Effectiveness in Holstein Friesians in Kenya

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Abstract:
This study was conducted to establish the effects of the inclusion of rumen protected methionine, RP-Met (Mepron®), in Holstein Friesian dairy cow rations on milk production, mastitis resistance, and cost effectiveness.Twelve Holstein Friesian dairy cows in early lactation and between first to third parity were randomly assigned into three dietary treatments in a completely randomized design, with four replications. The experiment was conducted over a period of 7 weeks. All animals were fed on corn silage and lucerne hay as basal diets. The treatment diets included a dairy meal balanced for amino acids using Mepron® (DMM), commercial dairy meal formulated based on crude protein (CMD), and farm formulated dairy meal based on crude protein (FDM). The treatment diets were provided to the animals at a rate of 10 kg per cow per day. Data on milk production, California mastitis test, and cost effectiveness were collected and then subjected to analysis of variance using R statistical software.The results showed that cows fed on DMM had higher (p<0.05) milk production (20.9 liters/day) compared to CMD (16.6 liters/day) and FDM (20 liters/day). Mastitis incidence analysis showed that scores zero and one were frequent in DMM, followed by FDM and CDM. Balancing dairy ration with Mepron® (DMM) reduced feed cost (USD 2.62) (p<0.05) compared to CDM (USD 2.64) and FDM (USD 3.25).From this study, it can be concluded that balancing dairy ration using rumen protected methionine resulted in enhanced milk production, lower incidences of mastitis and a cost-effective ration.
Key Word*:Rumen protected methionine, Holstein Friesian, Milk production, Mastitis, Cost effectiveness.*

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I. Introduction

Feed is a key input in dairy production value chain as it determines the productivity and, consequently, the profitability of the dairy enterprises (Britt et al 2021). In recent times, innovations and modern technology in animal nutrition have been applied to optimize animal productivity and health. In the nutrition of dairy animals, amino acids can be one of the limiting nutrients in the diets of the animals especially lactating dairy cows. This is particularly true for cows in early lactation when dry matter (DM) intake is relatively low, and the amino acid requirement is high (Ji and Dann 2013). In East Africa, some raw materials used as amino acid sources in dairy ration formulation include cotton seed cake, sunflower meal, sunflower cake, soybean meal, full fat soya, alfalfa, and copra are expensive, seasonal and scarce (ASARECA 2013).

For many years, dairy ration formulation has been based on common parameters such as energy, starch, fiber, protein, minerals and vitamins. Inherent in this approach is the problem that most of these nutrients are not what the animal body needs, especially in growth and production. This approach lacks the precision to make the correct informed decisions of nutrient balancing. Furthermore, there is the continual problem of ingredient availability and the rising cost of protein sources (Lukuyu and Gachuiri 2019). Most dairy rations, especially for high yielder dairy cattle, are formulated to contain a crude protein (CP) level of 17 to 18%. More protein sources are used to achieve this CP level, which results in expensive dairy feed (NRC 2001). Rumen microbial protein supplies over half of the amino acids absorbed by ruminants and is a relatively well-balanced protein source with an essential amino acid profile similar to that required for growth and milk production. However, rumen microbial protein synthesis alone cannot supply enough amino acids to meet the requirements of cows producing large quantities of milk (Hvelplund et al 2001). Therefore, optimising the supply of amino acids in dairy rations is important to improve protein utilization and increase milk production and solids. Supplementing dairy rations with rumen-protected amino acids limiting milk production and protein synthesis may compensate for metabolizable protein deficiency in most dairy cow rations, especially those formulated based on CP content (Sinclair 2013). It is generally accepted that methionine and lysine are most often the first limiting amino acids for milk production (Appuhamy 2014). The benefits of amino acid balancing in dairy cattle include improved dairy performance, liver function, fertility, reduced impact of dairy production on the environment and overall profitability (Nocek 2005).

Increasing evidence shows that dietary supplementation of specific amino acids enhances the immune status of animals to infectious diseases (Broderick et al 2014). Three major factors of sulfur amino acids, such as glutathione, homocysteine and taurin, influence mainly the inflammatory aspect of the immune response *in vitro* and *in vivo* (Misciattelli et al., 2013). Methionine intake transiently raises plasma glutathione, homocysteine and taurin (Robert 2006).

Glutathione scavenges for free radicles and other active oxygen species and conjugates with various electrophiles and xenobiotics for detoxification (Feng et al 2002). There is evidence that the intracellular concentrations of glutathione play an important role in regulating cellular signaling pathways (including the nuclear transcription factor pathway) in response to immunological challenges (Fratelli et al 2003). Methionine is the first limiting amino acid in milk production (Polan et al 1991). The ration needs to be high in its CP content to meet methionine requirements, which may be led to highly priced animal feed as CP sources are generally expensive. However, this requirement can be fulfilled by supplementing the dairy meal with RP-Met, which is more cost effective (Batistel 2017).In ruminant nutrition, commercially produced amino acids must be protected against microbial degradation in the rumen (Kung and Rode 1996). Rumen protected methionine is made by coating a small pellet of methionine with material that prevents rumen microbes from attacking the methionine but delivers a sufficient amount of methionine in the lower gut. Several materials have been commercially used to coat amino acids, for example, Ethyl-cellulose, copolymer, fats or fatty acids (Broderick et al 2014). It is important to evaluate the coating since it determines whether methionine will be slow-release post rumen, fast release post rumen or no-release (cow-protected) for some cases. Using rumen protected methionine enables balancing amino acids close to dairy cattle requirements in a more cost-effective manner (Lapierre 2017). Therefore, the objective of this study was to evaluate the effect of formulating dairy cow rations using rumen protected Methionine on milk production, resistance to mastitis and ration cost effectiveness in Kenya.

II. Material and Methods

Description of the Study area

The study was carried out at Molito Dairy Farm, located in Ngecha ward, Limuru sub-county, Kiambu County, Kenya. The farm is located at 1°11'10.3"S 36°42'14E. Limuru has a Marine west coast and a warm summer climate. The district's yearly temperature is 22.05ºC, which is -0.45% lower than Kenya's averages. Limuru typically receives about 137.44 millimeters of precipitation and has 226.84 rainy days annually (Andrew 2021).

Experimental design and study animals

Twelve Holstein Friesian dairy cows were randomly assigned to three treatment diets in a completely randomized design with four replications. The characteristics of the experimental animals were lactating animals in the early stage of lactation (less than 100 days) and in third parity or less. Each treatment had four lactating cows of similar parity, body condition, and size. All the cows recruited for this trial were within the transition period, usually less than 100-day post-calving when the methionine requirement is high. The feeding trial was conducted over a period of 7 weeks. The cows were sprayed with acaricide once every week for tick control, and their teats were dipped using Mastrite® (CKL Africa Limited, Nairobi, Kenya) after every milking to help control mastitis. California mastitis test kit was used three times every week to check for clinical and sub-clinical mastitis. The animals were housed in well-ventilated stalls and fed individually. Cows were moved to the adjacent milking pallor during the milking period. The milking herd were placed on a milking regime of three times per day, and milking was done using machine milking. Feeding was based on semi-total mixed ration where all forage feeds were mixed using a mixer wagon, and the concentrate portion of the ration was mixed separately and added to the other portion of the ration at a rate of 10 kg per cow per day.

Experimental feed and formulation

Feed ingredients used to formulate diets for dairy animals were sourced from local suppliers. Synthetic rumen protected methionine (Mepron®) was sourced from Evonik Industries Ltd, Nairobi, Kenya. Three experimental rations, including dairy meal balanced for amino acids using Mepron® (MDM), commercial dairy meal formulated based on crude protein (CDM), farm formulated dairy meal based on crude protein (FDM), were formulated to meet the nutrient requirements of the dairy animals (NRC 2001). The diets were formulated using TMR software AMINOCow® from Nittany Dairy Nutrition,and the concentrate portion using

Brill® formulation software (Table 1). Corn silage and Lucerne hay were used as additional forage components for all the animals in all the treatments.

Table 1: Total mixed ration (TMR) formulation (on as fed basis) of the treatment diets

Ingredient	MDM	CDM	FDM
Lucerne	5.00	5.00	5.00
Maize silage	20.1	21.5	19.5
Mepron® dairy meal	10.0	0.00	0.00
Commercial dairy meal	0.00	10.0	0.00
Farm dairy meal	0.00	0.00	10.0
Mineral lick	0.10	0.10	0.10
Estimated Feed intake	35.2	36.6	34.6

DMM, dairy meal balanced for amino acids using Mepron®; CDM, commercial dairy meal formulated based on crude protein; FDM, farm formulated dairy meal based on crude protein.

The mineral supplement was provided at the rate of 100 grams per cow per day, and water was provided *ad libitum*. Feed time was spread throughout the day, and major feeding was done at 10 am, then at 2 pm, then later at 6 pm after the evening milking. The concentrate portion ingredients were mixed at Unga Farm Care Ltd, Nairobi, Kenya, before being transported to the farm for experiment use (Table 2).

Table 2: Treatment diet formulation (kg/ton) and calculated nutrient composition

Ingredients	MDM	CDM	FDM
Wheat bran	350	350	119
Maize	258	250	265
Sunflower cake	100	100	172
Cotton seed cake	0.00	0.00	66.0
Soya bean meal	74.3	99.9	32.0
Canola cake	0.00	0.00	79.0
Wheat pollard	66.6	60.8	106
Maize germ/bran	60.0	50.6	106
Rice polish	60.0	50.0	0.00
Limestone	15.6	16.8	19.0
Macklik super	0.00	0.00	21.0
Diamond V XPC	0.00	0.00	1.00
Toxin Binder	0.00	0.00	1.00
Dairy premix	10.0	10.0	0.00
Kupakula	0.00	0.00	13.0
Urea	0.00	8.40	0.00
DCP	3.50	3.50	0.00
Mepron®	2.00	0.00	0.00
Total	1000	1000	1000
Cost/kg (USD)	0.27	0.27	0.33
Calculated nutrient composition of the experimental diets			
Nutrient composition	**DMM**	**CDM**	**FDM**
Crude protein (%)	15.5	16.2	17.4
Crude fiber (%)	9.09	11.4	8.66
Either extract (%)	5.10	4.83	5.22
MER (Kcal/kg)	2450	2405	2289
Calcium (%)	0.80	0.80	0.91
Total phosphorus (%)	0.82	0.81	0.69
Lysine (%)	0.69	0.74	0.77
Methionine (%)	0.44	0.28	0.34

MER, metabolizable energy for ruminants; MDM, dairy meal balanced for amino acids using Mepron®; CDM, commercial dairy meal formulated based on crude protein; FDM, farm formulated dairy meal based on crude protein

Data collection and chemical composition analysis

Body condition scoring was carried out on all the study animals at the beginning of the feeding trial and then weekly. The score used had values ranging from 1 to 5, where 1 is a very thin cow with no fat reserves and 5 is a severely over conditioned cow (Marija et al 2011). The body scores were carried out by two independent persons: the researcher, the farm manager, or a team member from Unga Farm Care Limited. Then the average score was calculated and recorded. The cows were milked three times daily at 10.00 am, 5.00 pm and 2.00 am. The milk produced per milking for each animal was weighed using a hook type of Hanson weighing scale that has an accuracy of 10 grams and can weigh up to a maximum of 100 kgs. California Mastitis Test (CMT) was done for all animals in each group for four quarters after every two days to monitor incidences of mastitis. Feed ingredients used to formulate the treatment diets were analyzed for crude protein (CP), crude fiber (CF), starch, sugar, acid detergent fibre (ADF), neutral detergent fibre (NDF), ash, energy and total amino acids using Near Infra-Red Reflectance (NIR) Method (Bruker machine, Tango Model, Opus software) (Sun et al 2016) at Evonik East Africa Satellite Laboratory in Nairobi, Kenya.

Data analysis

Analysis of variances was done for data on milk production of Holstein Frisian lactating cows fed different diets, California mastitis test, and cost effectiveness. When significance was detected, means was separated using the Student Newman Keuls (SNK) at $p<0.05$. All statistical analyses were performed using R software (Version 4.0.2) for windows (R Core Team 2020).

III. Results and Discussion

Ingredient proximate content (%DM basis)

The results of nutrient analysis of the feed ingredients used to formulate the treatment diets are shown in Table 3. The dry matter content of the ingredients ranged from 88.3% in Maize to 92.4 in cotton cake and Kupakula. The crude protein of Mepron® was 55%, which was higher than other ingredients. The neutral detergent fiber varied from 14.5% DM in maize to 46.1% in sunflower.

Table 3: Proximate analysis (%DM basis) of the ingredients used in the experiment

Ingredient	DM (%)	CP (%)	EE (%)	CF (%)	Ash (%)	Starch (%)	ADF (%)	NDF (%)	Sugar (%)	MER (Kcal/Kg)
Wheat bran	88.9	17.1	4.58	10.2	5.76	23.6	13.3	44.7	5.37	2105
Maize	88.3	9.2	5.21	2.54	1.41	71.6	4.07	14.5	1.17	3803
Sunflower	92.0	26.2	10.5	30.4	6.28	0.11	34.3	46.1	4.67	2623
Cotton cake	92.4	32.9	7.71	23.9	6.14	0.11	32.0	44.2	3.46	2675
Soybean meal	90.0	50.7	4.51	6.70	7.35	0.67	9.67	15.8	9.06	2678
Canola cake	92.1	39.3	8.74	11.9	7.67	0.11	20.4	28.4	8.25	2423
Wheat pollard	89.6	17.4	4.51	7.82	4.54	30.0	10.9	36.3	5.78	2533
Maize germ	88.6	11.2	10.5	5.85	3.39	46.2	7.54	27.7	3.16	3217
Rice polish	90.4	13.5	14.9	10.5	10.7	29.4	12.8	26.1	3.37	3010
Mepron®	91.0	55.0	1.10	3.30	1.64	-	-	-	-	4735
Kupakula	92.4	53.0	5.41	6.53	7.16	0.65	9.42	16.0	8.79	2608

DM, dry matter; CP, crude protein; EE, ether extract; CF, crude fiber; ADF, acid detergent fibre; NDF, neutral detergent fibre; MER, metabolizable energy for ruminant

Total amino acid (%DM basis) of the ingredients

Ten essential amino acid compositions of the ingredients were analyzed with special emphasis on the first, second and third limiting amino acids for dairy cows, namely methionine, lysine and histidine (Table 4). The methionine content of the ingredients ranged from 0.19 in maize to 0.76 in canola cake, which was insufficient to meet milk production requirements (NRC, 2001) unless supplemented from a synthetic source. The lysine content in the ingredient ranged from 0.29 in maize to 3.06 in soybean meal. This was appreciable, and the requirement for lysine could be met without necessarily supplementing with a synthetic source. The histidine content of the concentrate portion of the ingredients ranged from 0.27% in maize to 1.30% in soybean meal.

Table 4: Total amino acid analysis (%DM basis) of the ingredients

Ingredients	Met	Lys	His	M+C	Thr	Trp	Arg	Ile	Lue	Val
Wheat bran	0.25	0.68	0.46	0.59	0.54	0.28	1.18	0.53	1.02	0.79
Maize	0.19	0.29	0.27	0.39	0.33	0.07	0.45	0.31	1.05	0.44
Sunflower	0.54	0.89	0.62	0.97	0.90	0.35	2.06	1.05	1.63	1.23
Cotton cake	0.46	1.35	0.85	1.01	1.03	0.41	3.46	1.01	1.82	1.38
SBM	0.66	3.06	1.30	1.38	1.93	0.67	3.69	2.30	3.81	2.38
Canola Cake	0.76	2.11	1.02	1.75	1.66	0.53	2.43	1.54	2.68	1.99
Wheat Pollard	0.27	0.73	0.45	0.61	0.57	0.26	1.18	0.55	1.06	0.80
Maize germ	0.20	0.51	0.33	0.44	0.42	0.11	0.72	0.36	1.01	0.59
Rice polish	0.25	0.62	0.35	0.53	0.50	0.17	1.04	0.46	0.92	0.71
Kupakula	0.34	0.55	0.45	1.02	0.61		2.38	0.66	1.16	0.86

Mepron®	85.00									

Met, methionine; Lys, lysine; His, histidine; M+C, methionine and cysteine; Thr, threonine; Trp, Tryptophan; Arg, arginine; Ile, isoleucine; Leu, leucine; Val, valine

Calcium and phosphorous content (%DM basis) of the ingredients

The calcium content of the ingredients ranged from 0.05 in maize to 38% in limestone, and the phosphorus level of the ingredients used in the concentrate portion of the ration ranged from 0.29% in Maize to 18.2% in dicalcium phosphate (DCP) (Table 5).

Table 5: Calcium and phosphorous content (%DM basis) of the ingredient

Ingredient	**Calcium (%)**	**Total Phosphorous**
Wheat bran	0.16	1.12
Maize	0.05	0.29
Sunflower cake	0.38	1.00
Cotton seed cake	0.19	0.82
Soya bean meal	0.38	0.69
Canola cake	0.49	0.68
Wheat pollard	0.15	0.97
Maize germ/bran	0.05	0.91
Rice polish	0.09	1.74
Limestone	38.00	0.02
Macklik super	20.36	11.00
DCP	24.50	18.20

Nutrient composition of the treatment diets

The results for the chemical composition analysis of the treatment diets used in this experiment are shown in Table 6. The crude protein of dairy meal balanced for amino acids using Mepron® (MDM) was 16.5%, which was lower than the commercial dairy meal formulated based on crude protein (CDM) and farm formulated dairy meal based on crude protein (FDM). The CP levels in the treatment diets are adequate and meets the recommendations for lactating dairy cows in early lactation of a minimum of 16.5% (NRC, 2001). The diet balanced for amino acids using Mepron® met the minimum recommended level while the commercial and farm dairy meals exceeded the minimum recommendations.

Table 6: Nutrient content (%DM) of the treatment diets

Nutrients	**MDM**	**CDM**	**FDM**
Dry Matter	90.3	90.5	90.4
Crude Protein	16.5	19.8	20.1
Methionine	0.42	0.29	0.33
Lysine	0.72	0.80	0.77
Histidine	0.41	0.45	0.50
Cysteine	0.29	0.32	0.36
Methionine + Cysteine	0.71	0.61	0.70
Threonine	0.58	0.63	0.71
Arginine	1.10	1.22	1.42
Isoleucine	0.61	0.66	0.72
Leucine	1.22	1.29	1.42
Valine	0.78	0.84	0.93
Phenylalanine	0.73	0.79	0.90
Glycine	0.79	0.86	0.92
Proline	0.94	0.99	1.05
Alanine	0.82	0.87	0.94
Aspartic acid	1.38	1.25	1.61
Glutamine	2.96	3.20	3.56
NH3	0.38	0.56	0.50
SUM_WITH_NH3	14.8	16.2	17.6
SUM_WO_NH3	14.4	15.6	17.1
Supplemented Methionine	0.14	<0.01	<0.01
Supplemented Lysine	<0.02	<0.02	<0.02

MDM, dairy meal balanced for amino acids using Mepron®; CDM, commercial dairy meal formulated based on crude protein; FDM, farm formulated dairy meal based on crude protein

Lactation performance of Friesian cows fed the three treatment diets

The formulation of one of the treatment diets involved using rumen protected methionine Mepron® to balance the ration for amino acids and meet methionine requirements more efficiently. The results of this study showed an increase ($p>0.05$) in milk production of cows fed dairy meal balanced for amino acid rumen

protected methionine (Mepron®) (20.9 litres per day). This result is in line with Lee (2012) and Appuhamy (2014), who reported that methionine and lysine are most often the first limiting amino acids for milk production. However, the milk production of cows fed commercial dairy meal (16.6 litres per day) declined compared to cows fed farm dairy meal formulated based on crude protein (20.0 litres per day) (Table 7). The dietary level of crude protein (CP) is one of the most important factors in milk production. The amount of nitrogen (N) in dietary CP excreted in manure is about two to three times that in milk (Broderick 2013). Overfeeding of CP results in an energy cost to the animal. This cost is associated with converting excess protein to urea (Dinn et al 1998). This could explain why cows fed CDM had a decline in milk production even though its CP was higher than MDM.
Balancing dairy ration for amino acids (AA) is increasingly accepted in dairy nutrition. This is due to the desire to feed lower protein diets, high prices for protein supplements, an overall trend of higher milk protein prices, continued refinement and improvement of nutrition models, and increased availability of rumen-protected amino acids (RP-AA) (NRC 2001).

Table 7: Lactation performance of Friesian cows fed experimental diets

	MDM	CDM	FDM	SEM	P-value
Initial milk production	19.7	18.2	19.8	0.64	0.53
Final milk production	20.9[a]	15.6[b]	18.2[c]	0.67	0.00
Change in milk production	+	-	-		
Overall milk production	144[a]	116[b]	140[ab]	4.49	0.08
Average milk production	20.9[a]	16.6[b]	20.0[ab]	0.26	0.00

MDM, dairy meal balanced for amino acids using Mepron®; CDM, commercial dairy meal formulated based on crude protein; FDM, farm formulated dairy meal based on crude protein

From the result of this study, it was observed (Figure 1) that balancing ration for amino acid using RP-Met (Mepron®) sustained and enhanced high milk production compared to production from cows fed the commercial dairy meal and farm dairy meals formulated based on crude protein.

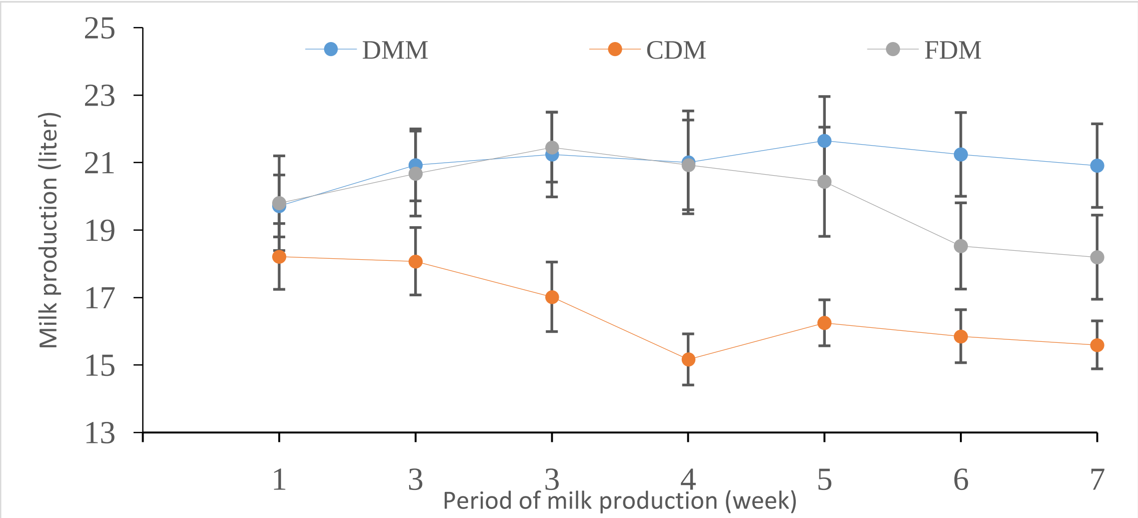

Figure 1: Weekly lactation performance (mean ± SE)

Effect of inclusion of rumen protected methionine on the cow's resistance to mastitis

The results on mastitis incidence are shown in Figures 2 and 3. Score Zero and one (negative mastitis in all four quarters) were more frequent in MDM, followed by FDM and CDM.

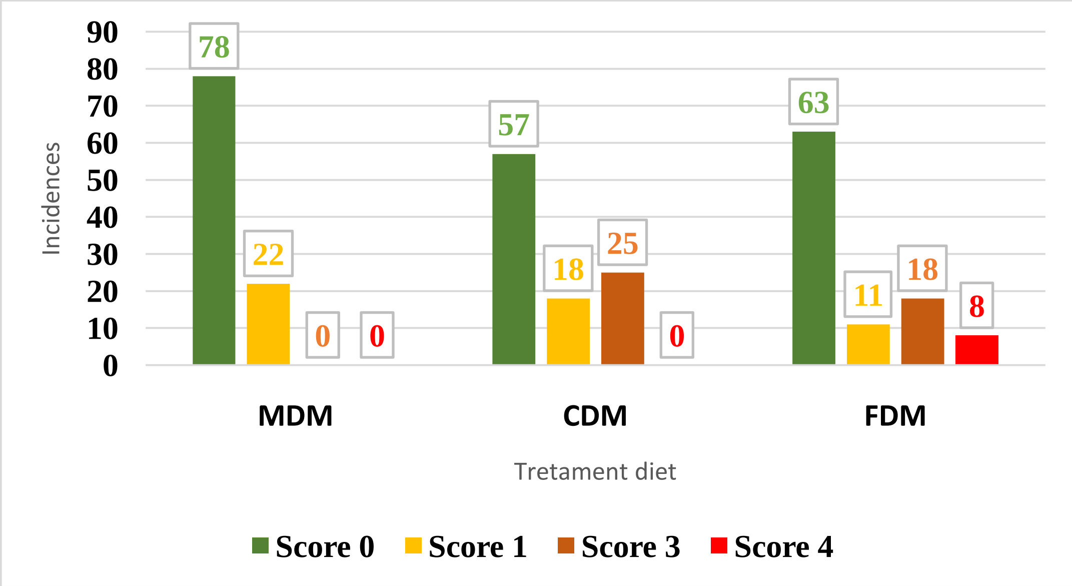

Figure 2: Mastitis incidences across treatments (Key: Score 0 = -Ve Mastitis, Score 1= Mastitis in one quarter, Score 2 = Mastitis in two quarters, Score 3 = Mastitis in three quarters and Score 4 = Mastitis in all the four quarters).

Interestingly, scores 3 and 4 were not detected in MDM, which may highlight the positive correlation between methionine adequacy from using rumen protected methionine and mastitis incidence. Meanwhile, score 3 was greater in CDM than in FDM. A high incidence of mastitis with a score of 4 was only found in CDM. According to Madsen and Nielsen (1981), while there is no definitive link between protein content in diets and mastitis incidence, there is however, more evidence regarding the harmful effect of N that is not in a protein form such as urea and ammonia on the mastitis incidence in milk-secreting tissues and various ducts throughout the udder can be damaged by bacterial toxins, and sometimes permanent damage to the udder occurs. Severe acute cases can be fatal, but even in cows that recover, there may be consequences for the rest of the lactation and subsequent lactations. Antibiotic therapy exists to control mastitis in dairy cows, but medication is expensive and is never guaranteed to heal effectively. The basic principle of mastitis control is to prevent new infections, but new cases of mastitis will inevitably occur. Once the infection is established in the udder, there are four ways to eliminate the disease: spontaneous cure, culling of chronically infected cows, and treatment during lactation and dry cow therapy. Among these four means of managing infections, antibiotic treatment is the principal method for eliminating cases of mastitis and is the primary reason for using antibiotics in dairy cows.

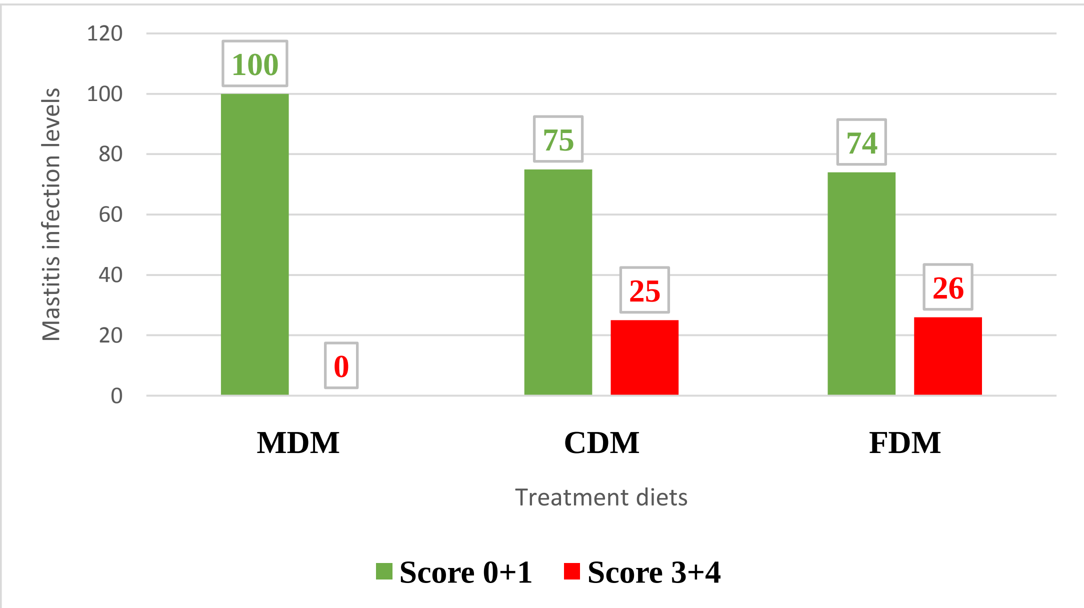

Figure 3: Mastitis Infection levels across treatments (Score 0 +1 = Negative Mastitis and positive mastitis in one quarter, Score 3+4 = Positive Mastitis in three quarters and positive mastitis in all the four quarters)

Balancing ration for amino acid, more so methionine using rumen protected methionine like Mepron® has benefits because methionine plays a key role in immunity as it is involved in the glutathione mechanism, which is the major antioxidant in cells that influence inflammatory aspects of the immune response as well as improving liver function, improving cows' fertility from low milk urea nitrogen, reduced impact of dairy production on the environment and overall profitability. Methionine has been implicated as having an important role in improving the immune system in dairy cattle. Supplying a rumen-protected Met supplement at a comparatively high level (30g/d) increased the proliferative response of peripheral T-lymphocytes in mid-lactation dairy cows. However, milk somatic cell count was not affected (Soder and Holden 1999). This is a possible explanation for why dairy cattle whose diets were supplemented with rumen protected methionine had lower incidences of mastitis in this study. This could be associated with the fact that; methionine plays a key role in immunity as it is involved in the glutathione mechanism, the major antioxidant in cells that influence inflammatory aspects of the immune response.

Ration cost effectiveness

Methionine is the first limiting amino acid for milk production. Meeting methionine requirements of lactating dairy cows by raising crude protein levels of the ration (18 to19%) through the use of some ingredients such as sunflower cake, copra, cotton seed cake, and soya bean meal is expensive in East Africa. This approach is also inaccurate and has been used before, mainly due to a lack of information on our local ingredients' amino acid composition. The high protein level in dairy feed is also associated with foot problems and fertility problems resulting from high milk urea nitrogen. The approach used to formulate the trial ration in this study involved using rumen protected Methionine Mepron® to balance the ration for amino acids and meet methionine requirements more efficiently. The results from this study showed that the MDM ration was cheaper (p>0.05) compared to CDM and FDM (Table 8). This result is also in line with William and Charles (1996), who found that it is possible to balance amino acids using rumen protected amino acids while reducing crude protein without compromising dairy cattle productivity.

Table 8: Cost-benefit analysis of balancing ration using RP-Met Mepron®

Costs	**DMM**	**CDM**	**FDM**	SEM	P-value
Average Milk production (L)	20.9^{a}	16.6^{b}	20.0^{ab}	0.64	0.01
Farm Gate Milk Prices (USD/L)	0.27	0.27	0.27	-	-
Revenue (per day)	5.76^{a}	4.56^{b}	5.49^{ab}	0.18	0.01
Concentrate feed rate (Kg/Day)	10.0	10.0	10.0	-	-
Cost (USD/Kg)	0.26^{b}	0.26^{b}	0.33a	0.00	0.00
Concentrate expense (per Day)	2.62^{c}	2.64^{b}	3.25^{a}	0.03	0.00
Total Income	3.15^{a}	1.92^{b}	2.24^{ab}	0.18	0.01
Margin from Feed (%)	49.4^{a}	38.9^{ab}	34.4^{b}	2.10	0.00

DMM, dairy meal balanced for amino acids using Mepron®; CDM, commercial dairy meal formulated based on crude protein; FDM, farm formulated dairy meal based on crude protein.

IV. Conclusion

The results of this study indicate that balancing dairy cow ration for amino acid using rumen protected methionine such as Mepron® increases milk production, improves resistance to mastitis and reduces feed cost.

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Disclosure statement

The authors reported no potential conflict of interest.

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