KENYA AGRICULTURAL RESEARCH INSTITUTE

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TOTAL MIXED RATIONS FOR DAIRY CATTLE IN MURANG'A COUNTY

A Technical Manual for Dairy Extension Workers and Farmers

A Publication of the Kenya Agricultural Research Institute

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List of abbreviations and acronyms

ADF	Acid Detergent Fibre
AEZ	Agricultural-ecological Zones
Ca	Calcium
CF	Crude Fibre
CP	Crude Protein
^{0}C	Degrees Celsius
DCP	Dicalcium phosphate
DM	Dry Matter
KARI	Kenya Agricultural Research Institute
KES	Kenya Shillings
Kg	Kilogramme
Km	Kilometre
LM	Lower Midlands
Max	Maximum
Mcal	Megacalories
Min	Minimum
mm	Millimetre
MU10Z1	Murang'a ration no. 1 for producing 10 kg milk/cow/day under zero grazing
MVI	Maximum Voluntary Intake
n	Number
NEL	Net Energy of Lactation
NDF	Neutral Detergent Fibre
NPN	Non-protein Nitrogen
NRC	National Research Council
P	Phosphorous
RUP	Rumen Undegradable Protein
RDP	Rumen Degradable Protein
SE	Standard Error
SPV	Sweet Potato Vines
TDN	Total Digestible Nutrients
UH	Upper Highlands
UM	Upper Midlands
ZG	Zero Grazing

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Foreword

In Kenya, dairy farming plays an important role in food security, employment creation, income generation to small-holder farmers, traders, processors and other participants engaged in the entire milk production and supply chain. Given the importance of the dairy sub-sector to the diets and incomes of poor smallholders, and the predicted increase in demand for milk and dairy products throughout the developing world, increased dairy productivity is critical. However, this is constraint by a number of factors key among them breeding, feeding and nutrition, and inadequate extension services.

Dairy cattle productivity is low due to lack of suitable dairy breeds, seasonal variations in quantity and quality of forages and the relatively high cost of concentrates among other factors. Furthermore, the increasing human population and the effects of climate change continue to diminish feed resources available to dairy cattle. The limits for existing dairy production systems are therefore being approached, if not exceeded, due to increasing demands for dairy feeds vis-a-vis availability. Intensification and efficiency in dairy production will be needed to increase productivity and reduce variable costs.

This manual provides information on formulation of cost-effective dairy ration options based on locally available feed resources in Murang'a County. The nutritionally balanced dairy rations, formulated using computer software, would help smallholder dairy farmers improve dairy productivity, food security, household income, employment opportunities and reduce production costs. These rations would also minimize feed wastage and environmental pollution through reduction of greenhouse gas emissions and element fluxes.

The manual was accomplished through concerted efforts of various institutions. Key to these was the Kenya Agricultural Research Institute who provided research scientists and facilities, World Bank International Development Association who provided financial support through the Eastern Africa Agricultural Productivity Project, and the University of Nairobi who were the main collaborators. I finally note with satisfaction that the exercise was successfully completed and the objectives of the project were met. It is therefore my sincere hope that the information contained in this document would be used by farmers, extension workers and other livestock stakeholders to formulate least cost balanced dairy feeds. The information would also be valuable in determining dairy feeding strategies in livestock feed resource centres in the specific county and other areas with similar climatic conditions in the Eastern Africa region.

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1.0 BACKGROUND INFORMATION

1.1 General information

The County of Murang'a is located in central Kenya and it is bordered by Nyeri County to the north, Nyandarua County to the west, Kiambu County to the south, Machakos County to the south east, Embu County to the east and Kirinyaga County to the north east (Figure 1).

Figure 1. Map showing the administrative counties in Kenya

(Source: ILRI, 2007. Kenya divisional boundaries as at the year 2000. International Livestock Research Institute (ILRI), Nairobi, Kenya. http://www.ilri.org)

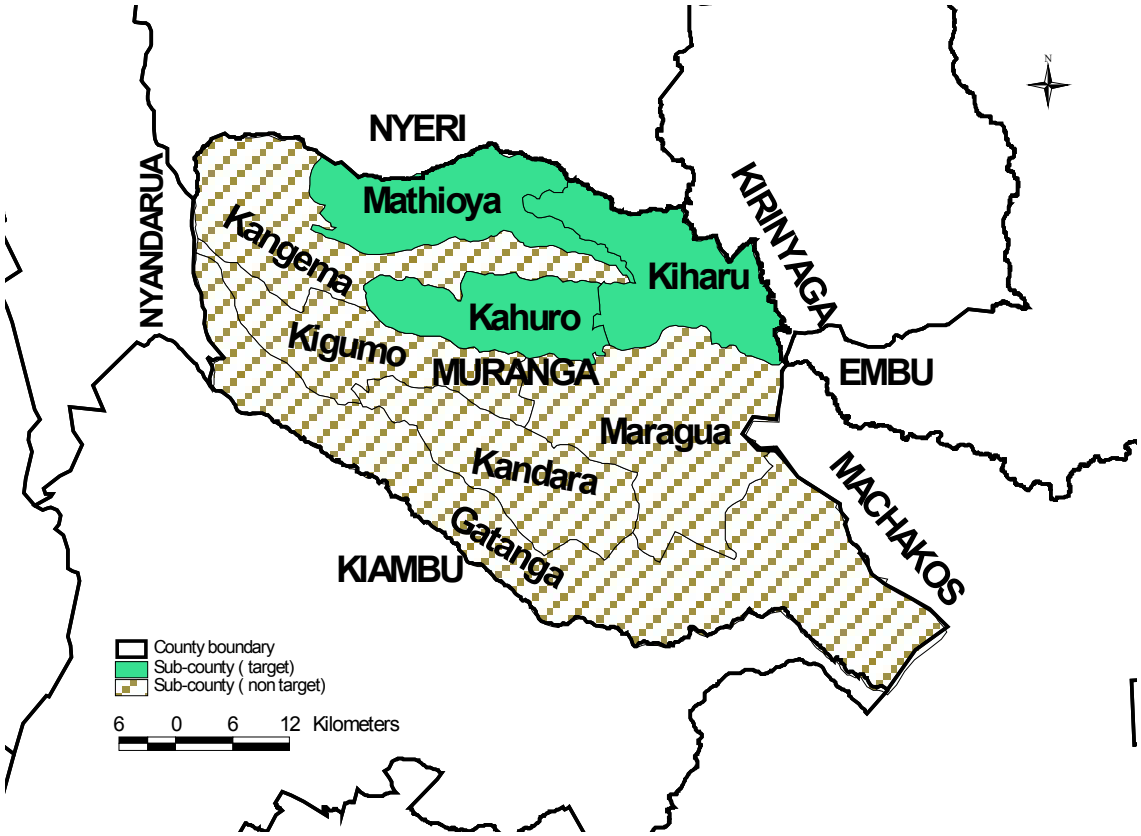

Figure 2. Map showing the administrative sub-counties in Murang'a County (Source: GoK, 2012. Preliminary report on the first review relating to the delimitation of boundaries and wards, 9th January 2012. The independent Electoral and Boundaries commission (IEBC), Kenya).

The County consists of eight sub-counties namely Mathioya, Kiharu, Kahuro, Gatanga, Kangema, Kigumo, Kandara, and Maragua (Figure 2). The general information and statistics of the county are shown in Table 1.

Table 1. General information and statistics on Murang'a County	
Population	942,581
Surface area (km²)	2,559
Density (people per km²)	368
Poverty rate, based on KIHBS (%)	29.9
Share of urban population (%)	16.3
Urban population in largest towns	
Makuyu	44,007
Murang'a	28,775
Maragua	26,374
Kabati	3,128
Kangari	2,810
Kiria-ini	2,457
Source: Commission on Revenue Allocation, 2011. General information and statistics of Murang'a County. Kenya: County Fact Sheets. www.crakenya.org	

The County is generally hilly with its lowest parts at an altitude of about 900 m while its highlands on the slopes of Aberdare Ranges lie at an altitude of over 3,300 m. Due to a wide range of altitudes, the agro-ecological zones (AEZ) are also very diverse from very cold (UH0) to hot and arid (LM4) zones. The AEZs are best described thus: wet, cold, steep and not recommended for agriculture (UH0) at an altitude of 2150-2500m, the Sheep and Dairy Zone (UH1), which extends to 2050m where the average temperature is 15°C. The next zones found in descending order on the eastern slopes of the Aberdare Ranges are the tea-dairy zone (LH1), the coffee-tea zone (UM1), the main coffee zone (UM2), the marginal coffee zone (UM3), and the sunflower-maize zone (UM4). A strip of UM3-UM4 occurs towards the east in the Kakuzi hills, although on less suitable soils which are very marginal for coffee growing. Down on the plains where cotton production is feasible, the area is dry (average annual rainfall is 800-900 mm).

Murang'a experiences reliable rainfall in two rainy seasons, a cool (10-25^{o}C) and wet (>1500mm average) "long rains" period in March-May and a warm (20-30^{o}C) during the "short-rains" (<1000mm) period in September-October. Variations in altitude, rainfall and temperature between its western highlands and its eastern lowlands coupled with the differences in the underlying geology of both volcanic and basement system rocks give rise to a variety of soil types. Highland areas have rich brown loamy soils suitable especially for tea, coffee, maize and dairy farming. They are also well-drained by streams and rivers. Low lying areas to the east of the County have black cotton soils and are generally flat. They are mostly farmed for subsistence crops including maize, beans, bananas, potatoes, and large-scale mango and pineapple plantations, among other crops.

The main agricultural products include tea, coffee, macadamia, milk, fish, honey, maize and beans. Over 80% of the population relies on agriculture while the rest are employed in the informal sector, tourism and manufacturing. The County is a hub of trade and commerce in the region partly due to its proximity to Nairobi and its high population. The County has dimmed over the years from being the cash cow of Kenya due to its lucrative tea and coffee industry, as the prices of these products suffered due to neglect and international competition. It is the reduced growth of these two crops that saw the emergence of other crops and value chains in a desperate measure by farmers to stay afloat. This has given rise to innovative small-scale farming mainly in banana, mango, maize, dairy and recently summer flowers and other horticultural produce meant for export. Other challenges facing the County include the oldest mean age in the country, and social issues such as alcoholism.

Agriculture, livestock farming and related activities form the backbone of the economy of the County. Most livelihoods (90%) are dominated by small-scale subsistence farming practiced on small family-owned land that continues to experience ever-growing population pressure and subsequently sub-division of land, much like the rest of the country. The result has been land and environmental degradation that has been made worse by global warming, causing re-current food shortages in parts of the County.

Dairy farming is widely practiced and ranks higher than crops in the County, with zero-grazing being the most common dairy production system. Previous studies have focused on economics of milk production among selected farmers in which feeding was shown to be a major constraint. Though inadequacy and availability of feeds is real, formulating the same to match the nutrients requirement for maintenance and production of dairy cattle is a main challenge. Lack of knowledge on quality of dairy feeds make the farmers most vulnerable to feed manufacturers and traders who market the dairy feeds in such labels as 'high grade', 'medium' or 'general' feeds without indicating the nutrient content. Most farmers rely on different sources of information on feeding, which are usually not reliable. This study sought to address this problem through a diagnostic survey to document available and common feed resources and then formulate wholesome rations that match the animal requirement for target level of milk production.

1.2 Diagnostic survey

A diagnostic survey was conducted from 7th-11th August 2011 in three Districts (Kahuro, agro-ecological zone UM2), Kiharu, agro-ecological zone UM3 and Mathioya, agro-ecological zones LH1 and UM2) in Murang'a County. The survey objectives were to establish the existing dairy feed resources and

feeding practices, dairy breeds and breeding practices, levels of dairy production, profitability of the dairy enterprise, and dairy farming challenges and opportunities.

The survey data consisted of both quantitative and qualitative variables. The data was analyzed among dairy production systems as independent variables using Microsoft Office Excel (2007). For each Statistic, comparisons were made among levels of each independent variable. Quantitative variables were analyzed by descriptive statistics while the qualitative variables were processed by counts and proportions using pivot tables generation procedure. Some results are highlighted in the sections 1.3 to 1.8.

1.3 Dairy production systems

In Kenya, farmers practice three main dairy production systems namely zero-grazing, semi-zero grazing and free grazing. Zero-grazing involves confining cattle to a limited physical space where they are managed, fed, watered, milked and often with supplemental feeding (Technoserve, 2008). Free grazing involves allowing cattle to obtain their basal forages through pastures grazing within or outside the farm, often with minimal supplemental feeds. Semi-zero grazing falls somewhere in the middle and involves the combination of the two approaches.

Slightly over 75% of the household heads interviewed during the survey were practicing zero-grazing (Table 2).

Table 2. Proportion (%) of household heads interviewed by production system

Production system	n	Percentage
Zero grazing	208	75.64
Semi-zero grazing	66	24.00
Production system not indicated	1	0.36
Total	**275**	**100.00**

On average, 74.2 % of the households were headed by males (Table 3). Furthermore, about 51% of the household heads were 50 years old and above (Table 3).

About 39% of household heads had secondary education as the highest formal education level (Table 4).

Table 3. Proportion (%) of gender and age group of household heads by production system

Production system	n	Male household heads (%)	Age group of household heads (years)			
			<35		>50	Age not Indicated
Zero grazing	208	76.92	8.17	38.94	50.96	1.92
Semi-zero grazing	66	66.67	6.06	36.36	51.52	6.06
Mean (n=274)		**74.18**	**8.00**	**38.18**	**50.91**	**2.91**

Table 4. Proportion (%) of household heads by highest level of formal education and production system

Production system	n	Highest formal education level					
		None	Primary	Secondary	Tertiary	University	Not indicated
Zero grazing	208	0.00	35.10	39.90	18.27	2.88	3.85
Semi zero grazing	66	1.52	37.88	37.88	6.06	1.52	15.15
Mean (n=274)		**0.36**	**36.00**	**39.27**	**15.27**	**2.55**	**6.55**

1.4 Dairy breeds and herd size

The Friesian dairy breed was the most popular as it was kept by about 80% of the households (Table 5). A higher proportion of households practicing zero-grazing kept Friesians as compared to those practicing semi-zero grazing (Table 5). Not surprisingly, crosses were more predominant under semi-zero grazing production systems (Table 5).

Table 5. Proportion (%) of households keeping various dairy cattle breeds by production system

Production system	n	Friesian	Ayrshire	Guernsey	Jersey	Crosses
Zero grazing	198	84.13	25.48	5.29	2.40	0.96
Semi-zero grazing	60	68.18	22.73	6.06	6.06	6.06
Mean (n=258)		**80.29**	**24.82**	**5.47**	**3.28**	**2.19**

The mean herd size in the County was about three animals, with lactating cows being a large proportion (46.3%) of the herd (Table 6).

Table 6. Dairy herd size and structure by production system

Production system	n	Herd size		Herd structure in relation to herd size (%)					
		Mean	SE	Lactating Cows	Dry Cows	Heifers	Weaned calves	Pre-weaned calves	Mature Bulls
Zero grazing	198	3.1	0.18	45.02	14.36	15.01	5.87	15.17	4.57
Semi-zero grazing	60	2.3	0.14	51.85	8.89	14.81	11.85	9.63	2.96
Mean (n=258)		**2.9**	**0.14**	**46.26**	**13.37**	**14.97**	**6.95**	**14.17**	**4.28**

1.5 Milk production

The average milk yield in the County was 8.5 kg/cow/day with farmers practicing zero grazing having a higher production from their dairy cows (Table 7). Cows in majority (77.05%) of the farms in the County produced 10 kg/day or less (Table 8). The average price of raw milk was KES 26.19 per kg (Table 9).

Table 7. Dairy cattle milk yields by production system

	Daily milk production per household (kg)			Daily milk production per cow (kg)		
Production system	**n**	**Mean**	**S.E.**	**n**	**Mean**	**S.E.**
Zero-grazing	185	14.45	1.178	295	9.06	0.305
Semi-zero grazing	59	7.65	0.792	73	6.18	0.399
Mean	**244**	**12.80**	**0.932**	**368**	**8.49**	**0.264**

Table 8. Proportion (%) of households by milk yield clusters and production system

Production system	n	Mean milk yield (kg/cow/day)				
		0.1-5	5.1-10	10.1-15	15.1-20	20.1-25
Zero grazing	**185**	29.73	42.70	20.00	5.41	2.16
Semi-zero grazing	**59**	50.85	40.68	6.78	1.69	0.00
Mean (n= 244)		**34.84**	**42.21**	**16.80**	**4.51**	**1.64**

Table 9. Prices (KES/Kg) of raw milk by production system			
Production system	**n**	**Mean**	**S.E**
Zero grazing	140	26.33	0.752
Semi-zero grazing	38	25.66	0.309
Mean (n=178)		**26.19**	**0.595**

1.6 Forage production

Almost all (98.2%) of the households grew Napier grass amongst other pastures and fodders (Table 10. A large proportion (89.5%) of the household heads interviewed were growing maize which would be provide both grain for human consumption and mainly maize stover for dairy feeding. The proportion of households growing fodder trees and other high protein forages was low (Table 11). The average farm size was 2.6 acres while the area under pastures and fodders was 0.8 acres (Table 12). The average number of fodder trees was 32.5 (Table 12). The average area under Napier grass was 0.7 acres (Table 13). Calliandra was the highest number (22) of fodder trees (Table 14).

Table 10. Households growing pastures and fodders by production system						
Production system	**n**	**Proportion (%) of households growing pastures and fodders**				
		Napier	**Maize**	**[1]Natural pastures**	**[2]Other fodders**	**[3]Other pastures**
Zero grazing	208	99.04	87.5	11.06	1.44	0.96
Semi zero grazing	66	96.97	96.97	6.06	1.52	0.00
Mean (n=274)		**98.18**	**89.45**	**9.82**	**1.45**	**0.73**

[1]Natural pastures included Panicum, Star, Bracharia and Eragrostis grasses. [2]Other fodders included Tithonia, Sorghum, green maize stalks, banana leaves and stems. [3]Other pastures included Columbus, Giant setaria, Nandi setaria, Sudan, Pokot and Guatemala grasses

Table 11. Households growing fodder trees and other high protein forages by production system								
Production system	**n**	**Proportion (%) of households growing fodder trees and other high protein forages**						
		Desmodium	**Calliandra**	**[1]SPV**	**Leucaena**	**Mulberry**	**Lucerne**	**Sesbania**
Zero grazing	208	19.71	17.79	15.87	11.06	9.13	3.37	1.92
Semi zero grazing	66	13.64	7.58	13.64	4.55	9.09	0.00	0.00
Mean (n=274)		**18.18**	**15.27**	**15.27**	**9.45**	**9.09**	**2.55**	**1.45**

[1]Sweet potato vines

Table 12. Farm size and pasture and fodder production by production system				
Production system	**Parameter**	**Farm size (acres)**	**Area under pastures and fodders (acres)**	**No. of fodder trees**
Zero grazing	n	202	192	46
	Mean	2.61	0.77	33.52
	SE	0.126	0.050	6.953
Semi-zero grazing	n	64	58	3
	Mean	2.68	0.70	16.67
	SE	0.259	0.101	4.410
County mean	**n**	**266**	**250**	**49**
	Mean	**2.63**	**0.76**	**32.49**
	SE	**0.114**	**0.045**	**6.553**

Table 13. Acreage under various forages by production system						
Production system	**Statistic**	**Napier grass**	**[1]Maize**	**Natural pastures**	**Desmodium**	**[2]SPV**
Zero grazing	n	191	163	23	23	23
	Mean	0.68	0.61	0.31	0.21	0.19
	SE	0.044	0.044	0.048	0.022	0.026
Semi-zero grazing	n	58	54	3	5	5
	Mean	0.62	0.82	0.42	0.40	0.27
	SE	0.087	0.102	0.083	0.217	0.099
Mean	**n**	**249**	**217**	**26**	**28**	**28**
	Mean	**0.66**	**0.66**	**0.33**	**0.24**	**0.20**
	SE	**0.039**	**0.042**	**0.044**	**0.042**	**0.027**
[1]Maize crop as a source of maize stover. [2]Sweet potato vines						

Table 14. Number of fodder trees per household by production system					
Production system	**Parameters**	**Calliandra**	**Mulberry**	**Leucaena**	**Sesbania**
Zero grazing	n	24	11	11	4
	Mean	22.8	22.6	28.1	22.5
	SE	5.37	12.97	11.48	9.47
Semi-zero grazing	n	1	3	2	-
	Mean	5.0	13.3	10.5	-
	SE	0.00	3.33	5.50	-
Mean	**n**	**25**	**14**	**13**	**4**
	Mean	**22.0**	**20.6**	**25.4**	**22.5**
	SE	**5.20**	**10.15**	**9.83**	**9.47**

1.7 Utilization of feeds by lactating cows

Farmers fed dairy cattle with various basal forages during the wet and dry seasons. The basal forages used during the wet season were Napier grass, maize stover, grass hay and natural pastures (Table 15). The basal forages used during the dry season were Napier grass, maize stover, banana leaves and stems, grass hay and natural pastures (Table 16).

Table 15. Proportion (%) of households feeding lactating cows with various basal forages during wet season by production system							
Production system	**n**	**Napier grass**	**Maize stover**	**Grass hay**	**Natural pastures**	**[1]Other basal forages**	**[2]Other crop residues**
Zero grazing	208	92.31	16.83	9.13	4.81	10.10	5.29
Semi-zero grazing	66	87.88	12.12	0.00	4.55	3.03	1.52
Mean (n=274)		**90.91**	**15.64**	**6.91**	**4.73**	**8.36**	**4.36**
[1] Other basal forages include weeds, maize silage, banana leaves and stems, vegetables, Rhodes grass and kikuyu grass. [2]Othe crop residues included rice straw and sorghum stover							

Table 16. Proportion (%) of households feeding lactating cows with various basal forages during dry season by production system							
Production systems	**n**	**Napier grass**	**Maize stover**	**Banana leaves & stems**	**Grass hay**	**Natural pasture**	**[1]Other basal forages**
Zero grazing	208	61.06	21.15	9.62	12.50	9.62	11.06
Semi-zero grazing	66	74.24	43.94	24.24	3.03	10.61	3.03
Mean (n=274)		**64.00**	**26.55**	**13.09**	**10.18**	**9.82**	**9.09**
[1]Other basal forages include weeds, maize silage, Rhodes grass, kikuyu grass, grevellia leaves, rice husks and straws.							

Forage supplements (e.g. fodder trees, legumes, sweet potato vines etc) were used by dairy farmers during wet and dry seasons. The forage supplements used during the wet season included sweet potato vines, desmodium, calliandra, mulberry and leucaena (Table 17).

The forage supplements used during the dry season included sweet potato vines, desmodium, mulberry, calliandra and leucaena (Table 18).

Table 17. Proportion (%) of households feeding lactating cows with various supplementary forages during wet season by production system

Production systems	n	[1]SPV	Desmodium	Calliandra	Mulberry	Lucerne	Leucaena	Other forages	[2]Supplementing (%)
Zero grazing	208	22.12	12.98	4.81	1.44	1.44	1.44	1.44	36.06
Semi-zero grazing	66	10.61	13.64	3.03	1.52	0.00	0.00	0.00	21.21
Mean (n=274)		**19.27**	**13.09**	**4.36**	**1.45**	**1.09**	**1.09**	**1.09**	32.36

[1]Sweet potato vines, [2]The % supplementing values are not a summation of the individual supplementary forage values since some households were using more than one supplement.

Table 18. Proportion (%) of households feeding lactating cows with various supplementary forages during dry season by production system

Production systems	n	[1]SPV	Desmodium	Mulberry	Calliandra	Leucaena	[2]Supplementing (%)
Zero grazing	208	12.50	8.17	2.40	2.40	1.44	20.67
Semi-zero grazing	66	12.12	4.55	0.00	0.00	0.00	13.64
Mean (n=274)		**12.36**	**7.27**	**1.82**	**1.82**	**1.09**	18.91

[1]Sweet potato vines, [2]The % supplementing values are not a summation of the individual supplementary forage values since some households were using more than one supplement.

Commercial concentrates were used by farmers during wet and dry seasons. Among the commercial concentrates, dairy meal was used by about 50% of the households during the wet season (Table 19). The other concentrates or feed ingredients used during the wet season were maize bran, maize germ, wheat pollard, and fish meal (Table 19).

Similarly, dairy meal was used by about 29% of the households during the dry season (Table 20). The other concentrates or feed ingredients used during the dry season were maize bran, maize germ, wheat pollard, and cotton seed cake (Table 20).

Table 19. Proportion (%) of households supplementing lactating cows with various commercial concentrates during wet season by production system

Production system	n	Dairy meal	Maize bran	Maize germ	Wheat pollard	Fish meal	[1]Supplementing (%)
Zero grazing	208	54.81	13.94	4.33	0.48	0.48	74.04
Semi-zero grazing	66	36.36	28.79	3.03	0.00	0.00	68.18
Mean (n=274)		**50.18**	**17.45**	**4.00**	**0.36**	**0.36**	72.36

[1]The % supplementing values are not a summation of the individual supplementary forage values since some households were using more than one supplement.

Table 20. Proportion (%) of households supplementing lactating cows with various commercial concentrates during dry season by production system

Production system	n	Dairy meal	Maize bran	Maize germ	Wheat pollard	Cotton seed cake	[1]Supplementing (%)
Zero grazing	208	28.37	14.90	3.37	0.96	0.48	48.08
Semi-zero grazing	66	30.30	24.24	3.03	0.00	0.00	57.58
Mean (n=274)		**28.73**	**17.09**	**3.27**	**0.73**	**0.36**	50.18

[1]The % supplementing values are not a summation of the individual supplementary forage values since some households were using more than one supplement.

Tables 21 and 22 indicate that farmers did supplement minerals to dairy cattle during the wet and dry seasons. Unga high phosphorous was used by about 35% of the farmers during the wet season (Table 21). Similarly, Unga high phosphorous was used by about 24% of the farmers during the dry season (Table 22). Other commercial mineral salts used during the wet and dry seasons were Maclic super, Vitaphos and Afya bora (Tables 21 and 22). About 80% and 59% of the farmers supplemented dairy cattle with minerals during the wet and dry seasons, respectively.

Table 21. Proportion (%) of households supplementing lactating cows with various mineral salts during wet season by production system

Production system	n	Unga high phosphorous	Maclic super	Vitaphos	Afya bora	[1]Supplementing (%)
Zero grazing	208	37.98	23.56	9.13	2.88	83.65
Semi-zero grazing	66	25.76	25.76	1.52	3.03	71.21
Mean (n=274)		**34.91**	**24.00**	**7.27**	**2.91**	**80.36**

[1]The % supplementing values are not a summation of the individual supplementary forage values since some households were using more than one supplement.

Table 22. Proportion (%) of households supplementing lactating cows with various mineral salts during dry season by production system						
Production system	**n**	**Unga high phosphorous**	**Maclic super**	**Vitaphos**	**Afya bora**	**[1]Supplementing (%)**
Zero grazing	208	25.00	15.38	7.21	2.40	56.73
Semi-zero grazing	66	19.70	27.27	3.03	1.52	65.15
Mean (n=274)		**23.64**	**18.18**	**6.18**	**2.18**	**58.55**
[1]The % supplementing values are not a summation of the individual supplementary forage values since some households were using more than one supplement.						

1.8 On-farm Ration formulation

The proportion of household heads trained on ration formulation was about 20 per cent (Table 23). On average, more farmers practicing zero-grazing were trained on ration formulation (Table 23).

Table 23. Proportion (%) of household heads trained on ration formulation by production system		
Production system	**n**	**Trained (%)**
Zero grazing	208	25.48
Semi-zero grazing	66	4.55
Mean (n=274)		**20.36**

Only farmers practicing zero-grazing formulated home-made concentrates (Table 24). In fact, only 3.9% of farmers formulated home-made concentrates during the wet season while only 0.48% formulated home-made concentrates during the dry season (Table 24).

However, home-made concentrate formulation mainly consisted of mixing energy or protein ingredients but the necessary technical know-how to balance nutrients in the formulated concentrates was lacking. The ingredients used were maize bran, maize germ, wheat pollard, cotton seed cake, dairy meal, fish meal and wheat bran. Furthermore, it was observed that farmers had no knowledge to make total mixed rations.

Table 24. Proportion (%) of households making home-made concentrates by season and production system			
Production system	**n**	**Season**	
		Wet	**Dry**
Zero grazing	208	3.85	0.48
Semi-zero grazing	66	0.00	0.00
Mean (n=274)		**2.92**	**0.36**

1.9 Objective

The main objective was to formulate least cost dairy ration options for lactating dairy cows using readily available feed resources and to document the information for ease of use by dairy farmers and other stakeholders in Murang'a County and other Eastern Africa regions with similar climatic conditions.

2.0 FORMULATION OF DAIRY RATIONS

2.1 PCdairy software

Dairy ration options for zero-grazing dairy production system were formulated using PCDAIRY WIN05 software package (Robinson and Ahmadi, 2005). The software consists of eight feed formulation modules based on the National Research Council (NRC, 1989) equations as follows;

(1) MAXIMZE – This module formulates feed rations for lactating cows that maximizes income over feed costs

(2) LC – This module formulates least cost rations for lactating or dry cows

(3) GROWING – This module formulates least cost rations for growing dairy cattle

(4) EVA-L – This module estimates nutrient content of ration being fed to lactating or dry cows and compares it with PCDairy standards, and estimates amount of milk that is possible from the ration as well as showing limiting nutrients

(5) EVA-G – This module estimates nutrient content of ration being fed to growing dairy animal, compares it with PCDairy nutrient standards, and estimates the amount of body weight gain that is possible from the ration as well as showing limiting nutrients

(6) FEEDLIST – This module allows users to set up a customized list of feed ingredients for use in any of the above programs

(7) DELIVERY – This module is a spreadsheet program for loading ration ingredients into a mixer for a specified number of cows, and for unloading the mixed ration to a specified number of cows

(8) FEEDTAG – This module calculates the energy content of feeds based on their chemical analysis

The least cost module was used to formulate rations for lactating cows based on the information provided in section 2.2. The information in the PCdairy printout included animal information, quantity of feed ingredients in the ration, quality and intake of the ration, forage: concentrate ratio, cost of ration, and the required nutrients based on animal information provided in sections 2.3 and 2.4

2.2 Information required for formulating dairy rations

The main information required to formulate dairy rations included:-

(1) Cow information. The assumptions were:- Live-weight = 400 kg, target milk yield per cow* = 10, 15, 20 or 25 kg, live-weight changes = -0.500 kg/day, percentages of milking herd in first = 10% and second = 20% lactations, Net energy of lactation (NEL) factor added for activity of the cow for ZG=10%, milk butter fat = 3.5%, and average days in milk = 21+

*The mean milk yield was 8.5 kg/cow/day in the County (see Table 7). Since the project intends to increase this milk yield by at least 30%, the lowest target milk yield should be 10 kg/ cow/ day. Furthermore, to cater for farmers with milk yields higher than 10 kg/cow/day, dairy ration options were formulated to produce 15-25 kg/cow/day.

(2) Nutrient constraints e.g. CP, NDF, Ca and P (which are inbuilt in software).

(3) Feed list including the common basal forages (Tables 15 and 16), forage supplements (Tables 17 and 18), commercial concentrates and feed ingredients (Tables 19 and 20), and mineral salts (Tables 21 and 22) fed to dairy cattle. In addition, less expensive and readily available mineral salts not indicated in Tables 21 and 22 were also included in the feed inventory data.

(4) The quality of the dairy feed resources was obtained from the alternative library of PCDairy. The alternative library was developed based on Kenyan dairy feed resource and their prices were provided by Murang'a County livestock production officers as detailed in Table 25.

Table 25. Quality and cost of dairy feed resources in Murang'a County

Feed resources	DM	CP	CF	Ash	Ca	P	MVI	[2]Cost (KES/kg as fed)
Napier grass (young maturity)	15.50	11.0	33.7	17.7	0.38	0.34	1.2	1.00
Napier grass (medium maturity)	17.50	8.0	36.1	12.4	0.60	0.41	1.3	2.00
Natural grass (medium maturity)	30.20	9.0	33.3	7.4	0.40	0.20	1.3	0.60
[1]Natural pastures (old maturity)	35.00	7.5	39.2	8.5	0.40	0.20	1.4	1.00
Banana stems	7.90	2.7	30.1	19.8	1.35	0.44	1.4	0.30
Banana leaves	16.40	8.5	31.2	13.0	1.04	0.19	1.3	0.30
Rhodes grass hay	85.00	8.0	40.0	10.0	0.50	0.31	1.3	13.30
Maize stover	80.00	4.3	37.9	6.5	0.35	0.19	1.4	0.50
Sweet potato vines	10.30	17.5	15.0	9.3	1.16	0.42	1.0	2.40
Calliandra leaves	21.90	22.4	15.0	12.0	0.90	0.15	1.2	2.50
Leucaena leaves	24.10	21.6	18.1	10.5	0.54	0.29	1.2	2.50
Desmodium	22.30	18.3	30.3	11.1	1.27	0.55	1.1	2.40
Mulberry	19.80	22.3	15.9	16.6	2.73	0.28	1.1	2.50
Lucerne hay	85.00	16.0	32.0	8.1	1.4	0.24	1.0	20.00
Dairy meal (standard)	95.00	16.0	12.2	7.0	0.60	0.40	-	31.00
Dairy meal (high yielder)	95.00	18.0	12.2	7.0	0.70	0.50	-	37.00
Cotton seed cake	92.00	35.0	23.2	6.6	0.19	0.20	-	60.00
Soya cake	87.90	47.7	6.7	7.1	0.38	0.69	-	60.00
Maize bran	90.00	12.0	12.0	3.0	0.10	0.05	-	15.00
Maize germ	91.00	14.0	15.2	7.0	0.10	0.50	-	20.00
Wheat bran	87.60	16.9	11.3	6.4	0.14	0.65	-	15.0
Wheat pollard	90.00	16.0	5.0	2.8	0.13	0.40	-	23.30
Mineral pre-mix	89.00	0.0	0.0	70.5	18.51	11.00	-	70.00
Di-calcium phosphate	97.00	0.0	0.0	86.8	22.0	19.3	-	350.00
Stock lime	100.00	0.0	0.0	95.8	34.0	0.02	-	7.00
Cane molasses	74.00	4.2	0.0	8.6	0.90	0.10	-	20.00

DM=dry matter, CP=crude protein, CF = crude fibre, Ca=calcium, P=phosphorous, MVI=maximum voluntary intake factor (range 1-1.4: excellent quality = 1, fair quality = 1.4)
[1]Natural pastures included panicums, kikuyu grass, star grass, hyparrhenia, couch grass
[2]Costs were estimated in a workshop involving the investigators and District Livestock Production Officers and other extension officers in Murang'a County

2.3 Formulated dairy ration options

The rations were formulated based on the selected anticipated levels of milk production viz. 10, 15, 20 and 25 kg per cow per day. The quantities of ingredients used in formulation of some dairy rations are as indicated in Tables 26 to 29. For ease of reference, the rations have been classified based on the predominant feed ingredient(s). Hence, the classes of the rations are based on Napier grass, Rhodes grass hay, maize stover, lucerne hay, green maize stalks or forage mixtures.

Furthermore, the rations have been coded. For example, MU10Z1 means Murang'a ration no 1 for producing 10 kg milk per cow per day under zero-grazing dairy production system. Similarly, MU15Z6 means Murang'a ration no 6 for producing 15 kg milk per cow per day under zero-grazing dairy production system.

Table 26. Dairy ration options for producing 10 kg milk/cow/day by a cow weighing 400kg under zero grazing production system																			
Ration code	Nature of ration	Ration ingredients															Total Ration (kg/cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MB	[11]MG	[12]SBC	[13]CSC	[14]SL	[15]DCP			
Napier grass based rations																			
MU10Z1	DM basis (kg)	7.36									5.79			0.37	0.04	0.05	13.60	185.68	54:46
	As fed basis (kg)	47.48									6.43			0.40	0.04	0.05	54.40		
MU10Z2	DM basis (kg)	5.54						1.82			4.49				0.48	0.02	13.35	139.83	60:40
	As fed basis (kg)	35.72						8.18			4.99				0.48	0.02	49.38		
MU10Z3	DM basis (kg)	5.21					2.15				4.79					0.06	12.20	158.16	59:41
	As fed basis (kg)	33.62					9.82				5.32					0.06	48.81		
MU10Z4	DM basis (kg)	5.89				1.47					7.72				0.12	0.07	15.26	225.34	48:52
	As fed basis (kg)	37.99				14.29					8.57				0.12	0.07	61.04		
MU10Z5	DM basis (kg)	5.18							2.18		0.34	1.38			0.52		9.60	124.29	77:23
	As fed basis (kg)	33.43							2.56		0.38	1.51			0.52		38.41		
Rhodes grass hay based rations																			
MU10Z6	DM basis (kg)		7.36								3.87			1.30	0.01	0.04	12.58	276.80	59:41
	As fed basis (kg)		8.66								4.30			1.42	0.01	0.04	14.42		
MU10Z7	DM basis (kg)		5.15					2.21			3.90	0.36	0.17				11.79	188.51	62:38
	As fed basis (kg)		6.06					9.90			4.33	0.40	0.19				20.88		

Table 26. Dairy ration options for producing 10 kg milk/cow/day by a cow weighing 400kg under zero grazing production system																			
Ration code	**Nature of ration**	**Ration ingredients**															**Total Ration (kg/cow/ day)**	**Cost (KES/ cow/ day)**	**Forage : Concentrate ratio**
		[1]YNG	**[2]RGH**	**[3]GMS**	**[4]MS**	**[5]SPV**	**[6]CL**	**[7]D**	**[8]LH**	**[9]WB**	**[10]MB**	**[11]MG**	**[12]SBC**	**[13]CSC**	**[14]SL**	**[15]DCP**			
MU10Z8	DM basis (kg)		5.25				2.11				5.85					0.08	13.29	229.59	55:45
	As fed basis (kg)		6.18				9.63				6.50					0.08	22.38		
MU10Z9	DM basis (kg)		5.89			1.47					2.97			0.69		0.02	11.04	227.32	67:33
	As fed basis (kg)		6.93			14.29					3.30			0.74		0.03	25.29		
MU10Z10	DM basis (kg)		5.14						4.86		0.38	0.58					10.95	211.87	91:9
	As fed basis (kg)		6.05						5.71		0.42	0.63					12.82		
MU10Z11	DM basis (kg)		4.45						2.25		2.84				0.14		9.68	169.56	69:31
	As fed basis (kg)		5.24						2.51		3.25				0.14		11.13		
Maize stover based rations																			
MU10Z12	DM basis (kg)				7.36							0.63	1.57		0.04	0.01	9.61	144.90	77:23
	As fed basis (kg)				9.20							0.70	1.74		0.04	0.01	11.69		
MU10Z13	DM basis (kg)				3.45				3.25	2.69							9.39	120.60	71:29
	As fed basis (kg)				3.71				3.64	3.07							10.42		
Forage mixtures based rations																			
MU10Z14	DM basis (kg)	5.67	1.69								2.53			0.57	0.03	0.03	10.51	151.35	70:30
	As fed basis (kg)	36.56	1.99								2.81			0.62	0.03	0.03	42.03		
MU10Z15	DM basis (kg)	5.56	1.70					1.24			3.06			0.20	0.01		11.76	139.16	72:28
	As fed basis (kg)	35.84	2.00					5.58			3.40			0.22	0.01		47.03		
MU10Z16	DM basis (kg)	5.57	1.70				1.22				3.28				0.00	0.03	11.80	140.50	72:28
	As fed basis (kg)	35.94	2.00				5.59				3.64				0.00	0.03	47.19		

Table 26. Dairy ration options for producing 10 kg milk/cow/day by a cow weighing 400kg under zero grazing production system

Ration code	Nature of ration	Ration ingredients															Total Ration (kg/cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MB	[11]MG	[12]SBC	[13]CSC	[14]SL	[15]DCP			
MU10Z17	DM basis (kg)	3.24	2.65			1.47					2.79			0.26		0.02	10.43	167.93	71:29
	As fed basis (kg)	20.92	3.11			14.29					3.10			0.28		0.03			
MU10Z18	DM basis (kg)	5.73			1.63						2.42			0.83	0.03	0.03	10.67	144.68	69:31
	As fed basis (kg)	36.99			2.03						2.69			0.90	0.03	0.04	42.67		
MU10Z19	DM basis (kg)	5.53			2.07			0.85			2.12			0.72	0.01	0.01	11.31	132.07	75:25
	As fed basis (kg)	35.69			2.59			3.79			2.36			0.78	0.01	0.01	45.23		
MU10Z20	DM basis (kg)	5.57			3.62		2.30				1.26			0.43		0.03	13.22	124.35	87:13
	As fed basis (kg)	35.96			4.53		10.50				1.41			0.47		0.03	52.89		
MU10Z21	DM basis (kg)	3.12			2.77	1.47					2.15			0.73		0.04	10.28	153.46	72:28
	As fed basis (kg)	20.14			3.46	14.29					2.39			0.79		0.04	41.12		
MU10Z22	DM basis (kg)	4.85			2.85							0.62	0.73		0.05		9.10	103.96	85:15
	As fed basis (kg)	31.30			3.56							0.68	0.81		0.05		36.40		
MU10Z23	DM basis (kg)	4.05		1.45					1.21	1.85					0.13		8.67	90.61	77:23
	As fed basis (kg)	26.10		5.01					1.35	2.11					0.13		34.69		

[1]Young Napier grass, [2]Rhodes grass hay, [3]Green maize stalk, [4]Maize stover, [5]Sweet potato vines, [6]Calliandra dry leaves, [7]Desmodium, [8]Lucerne hay, [9]wheat bran, [10]Maize bran, [11]Maize germ, [12]Soya bean cake, [13]Cotton seed cake, [14]stock lime, [15]Di-calcium Phosphate

Table 27. Dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400kg under zero grazing production system																			
Ration code	Nature of ration	Ration ingredients															Total Ration (kg/cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MB	[11]MG	[12]SBC	[13]CSC	[14]SL	[15]DCP			
Napier grass based rations																			
MU15Z1	DM basis (kg)	7.36									5.76	1.77		2.57	0.10	0.09	17.64	384.18	42:58
	As fed basis (kg)	47.48									6.40	1.94		2.79	0.10	0.10	58.81		
MU15Z2	DM basis (kg)	5.15						2.21			4.34	3.01	0.93		0.08	0.00	15.71	268.78	47:53
	As fed basis (kg)	33.24						9.90			4.82	3.31	1.04		0.08	0.00	52.38		
MU15Z3	DM basis (kg)	5.15					2.21				6.92			1.36	0.01	0.14	15.79	312.71	47:53
	As fed basis (kg)	33.24					10.08				7.69			1.48	0.01	0.14	52.65		
MU15Z4	DM basis (kg)	6.62				0.74					8.50			2.66	0.06	0.15	18.73	428.84	39:61
	As fed basis (kg)	42.74				7.15					9.45			2.89	0.06	0.15	62.43		
MU15Z5	DM basis (kg)	4.60							2.76		0.49	2.67	0.61		0.00		11.13	208.58	66:34
	As fed basis (kg)	29.69							3.24		0.54	2.94	0.67		0.00		37.09		
Rhodes grass hay based rations																			
MU15Z6	DM basis (kg)		12.11										2.61		0.04		14.77	388.83	82:18
	As fed basis (kg)		14.25										2.90		0.04		17.20		
MU15Z7	DM basis (kg)		5.15					2.21			3.39	1.61	1.25		0.03		13.65	292.20	54:46
	As fed basis (kg)		6.06					9.90			3.77	1.77	1.39		0.03		22.92		
MU15Z8	DM basis (kg)		5.89				1.47				5.72		1.50		0.02	0.09	14.69	349.67	50:50
	As fed basis (kg)		6.93				6.72				6.36		1.67		0.02	0.09	21.78		

Table 27. Dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400kg under zero grazing production system																			
Ration code	Nature of ration	Ration ingredients															Total Ration (kg/cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MB	[11]MG	[12]SBC	[13]CSC	[14]SL	[15]DCP			
MU15Z9	DM basis (kg)		9.10			1.01					1.70		2.04		0.03		13.87	349.59	73:27
	As fed basis (kg)		10.70			9.81					1.89		2.26		0.03		24.69		
MU15Z10	DM basis (kg)		0.09						7.27		0.85	3.83				0.02	12.06	277.73	61:39
	As fed basis (kg)		0.10						8.56		0.95	4.21				0.02	13.80		
MU15Z11	DM basis (kg)		1.70						5.00	4.68					0.06		11.45	219.07	59:41
	As fed basis (kg)		2.00						5.59	5.35					0.06		13.00		
Maize stover based rations																			
MU15Z12	DM basis (kg)				7.36							1.60	2.50		0.08	0.01	11.53	236.22	64:36
	As fed basis (kg)				9.20							1.75	2.77		0.08	0.01	13.81		
MU15Z13	DM basis (kg)				1.36				5.35	4.62							11.32	199.45	59:41
	As fed basis (kg)				1.46				5.98	5.28							12.71		
Forage mixtures based rations																			
MU15Z14	DM basis (kg)	5.20	2.16								3.64		1.48		0.06	0.03	12.57	254.43	59:41
	As fed basis (kg)	33.58	2.54								4.04		1.64		0.06	0.04	41.89		
MU15Z15	DM basis (kg)	4.31	1.17					2.35			4.99			1.69	0.01	0.07	14.58	287.64	54:46
	As fed basis (kg)	27.77	1.38					10.53			5.54			1.83	0.01	0.07	47.14		
MU15Z16	DM basis (kg)	4.78	1.10				1.48				4.72			1.59	0.02	0.10	13.79	283.62	53:47
	As fed basis (kg)	30.83	1.30				6.75				5.24			1.73	0.02	0.10	45.97		

Table 27. Dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400kg under zero grazing production system

Ration code	Nature of ration	Ration ingredients															Total Ration (kg/cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MB	[11]MG	[12]SBC	[13]CSC	[14]SL	[15]DCP			
MU15Z17	DM basis (kg)	5.15	1.10			1.10					7.36			2.51	0.04	0.13	17.40	409.02	42:58
	As fed basis (kg)	33.24	1.30			10.72					8.18			2.73	0.04	0.13	56.34		
MU15Z18	DM basis (kg)	6.99			0.37						6.91	1.47		2.87	0.09	0.12	18.82	423.33	39:61
	As fed basis (kg)	45.11			0.46						7.68	1.62		3.12	0.09	0.12	58.20		
MU15Z19	DM basis (kg)	5.15			1.10			1.10			8.28			2.83	0.05	0.15	18.66	420.73	39:61
	As fed basis (kg)	33.24			1.38			4.95			9.21			3.07	0.05	0.15	52.04		
MU15Z20	DM basis (kg)	5.15			1.10		1.10				7.03			2.41	0.04	0.15	16.98	373.45	43:57
	As fed basis (kg)	33.24			1.38		5.04				7.81			2.61	0.04	0.15	50.28		
MU15Z21	DM basis (kg)	5.15			1.10	1.10					6.46	1.31		2.65	0.06	0.11	17.96	409.92	41:59
	As fed basis (kg)	33.24			1.38	10.72					7.18	1.44		2.88	0.06	0.12	57.02		
MU15Z22	DM basis (kg)	4.51			2.85						0.32	1.64	1.60		0.08		11.00	197.37	67:33
	As fed basis (kg)	29.09			3.56						0.36	1.80	1.78		0.08		36.67		
MU15Z23	DM basis (kg)	1.52		0.67					4.51	4.29					0.07		11.05	186.89	61:39
	As fed basis (kg)	9.80		2.32					5.05	4.89					0.07		22.12		

[1]Young Napier grass, [2]Rhodes grass hay, [3]Green maize stalk, [4]Maize stover, [5]Sweet potato vines, [6]Calliandra dry leaves, [7]Desmodium, [8]Lucerne hay, [9]wheat bran, [10]Maize bran, [11]Maize germ, [12]Soya bean cake, [13]Cotton seed cake, [14]stock lime, [15]Di-calcium Phosphate

Table 28. Dairy ration options for producing 20 kg milk/cow/day by a cow weighing 400kg under zero grazing production system																			
Ration code	**Nature of ration**	**Dairy ration ingredients**															**Total Ration (Kg/ cow/ day)**	**Cost (KES/ cow/ day)**	**Forage : Concentrate ratio**
		[1]YNG	**[2]RGH**	**[3]GMS**	**[4]MS**	**[5]SPV**	**[6]CL**	**[7]D**	**[8]LH**	**[9]WB**	**[10]MG**	**[11]MB**	**[12]CSC**	**[13]SBC**	**[14]SL**	**[15]DCP**			
Napier grass based rations																			
MU20Z1	DM basis (kg)	7.36									1.77	5.76	2.57		0.10	0.09	17.64	384.18	42:58
	As fed basis (kg)	47.48									1.94	6.40	2.79		0.10	0.10	58.81		
MU20Z2	DM basis (kg)	6.62						0.74				7.08	2.39		0.05	0.12	17.00	367.92	43:57
	As fed basis (kg)	42.74						3.30				7.87	2.60		0.05	0.12	56.68		
MU20Z3	DM basis (kg)	6.62					0.74					7.21	2.27		0.05	0.14	17.03	368.79	43:57
	As fed basis (kg)	42.74					3.36					8.01	2.47		0.05	0.14	56.77		
MU20Z4	DM basis (kg)	6.68				0.74						8.50	2.66		0.06	0.15	18.73	428.84	39:61
	As fed basis (kg)	42.74				7.15						9.45	2.89		0.06	0.15	62.43		
MU20Z5	DM basis (kg)	4.32							3.58		4.09	0.33		0.99	0.02		13.33	284.65	59:41
	As fed basis (kg)	27.90							4.21		4.50	0.36		1.10	0.02		38.09		
Green maize stalk based ration																			
MU20Z6	DM basis (kg)			2.01					4.69	5.10			1.07		0.26		13.14	272.48	51:49
	As fed basis (kg)			6.96					5.25	5.83			1.19		0.26		19.48		
Lucerne hay based ration																			
MU20Z7	DM basis (kg)								7.36		3.61	2.54		0.58		0.07	14.16	364.16	52:48
	As fed basis (kg)								8.66		3.96	2.83		0.65		0.07	16.16		
Rhodes grass hay based rations																			

Table 28. Dairy ration options for producing 20 kg milk/cow/day by a cow weighing 400kg under zero grazing production system																				
Ration code	**Nature of ration**	**Dairy ration ingredients**															**Total Ration (Kg/ cow/ day)**	**Cost (KES/ cow/ day)**	**Forage : Concentrate ratio**
		[1]YNG	**[2]RGH**	**[3]GMS**	**[4]MS**	**[5]SPV**	**[6]CL**	**[7]D**	**[8]LH**	**[9]WB**	**[10]MG**	**[11]MB**	**[12]CSC**	**[13]SBC**	**[14]SL**	**[15]DCP**			
MU20Z8	DM basis (kg)		7.36									6.02		2.19	0.06	0.07	15.69	406.96	47:53
	As fed basis (kg)		8.66									6.69		2.43	0.06	0.07	17.91		
MU20Z9	DM basis (kg)		6.62					0.74				6.75		2.02	0.05	0.07	16.24	404.10	45:55
	As fed basis (kg)		7.79					3.30				7.50		2.24	0.05	0.07	20.95		
MU20Z10	DM basis (kg)		6.04				1.33				1.72	6.59	2.83		0.04	0.13	18.66	486.72	39:61
	As fed basis (kg)		7.10				6.05				1.89	7.32	3.07		0.04	0.14	25.61		
MU20Z11	DM basis (kg)		6.62			0.74						6.00		1.96	0.04	0.07	15.43	394.59	48:52
	As fed basis (kg)		7.79			7.15						6.67		2.18	0.04	0.07	23.89		
MU20Z12	DM basis (kg)		1.34						5.36	5.91			0.65		0.25		13.51	287.05	50:50
	As fed basis (kg)		1.58						6.00	6.75			0.72		0.25		15.29		
Maize stover based rations																			
MU20Z13	DM basis (kg)				7.36						3.07			2.98	0.12	0.01	13.54	307.91	54:46
	As fed basis (kg)				9.20						3.37			3.31	0.12	0.01	16.01		
MU20Z14	DM basis (kg)				1.34				5.36	5.65			0.86		0.22		13.43	275.82	50:50
	As fed basis (kg)				1.44				6.00	6.45			0.95		0.22		15.06		
Forage mixtures based rations																			
MU20Z15	DM basis (kg)	6.62	0.74								1.49	6.80	2.83		0.09	0.12	18.69	426.89	39:61
	As fed basis (kg)	42.74	0.87								1.64	7.55	3.08		0.09	0.12	56.08		

Table 28. Dairy ration options for producing 20 kg milk/cow/day by a cow weighing 400kg under zero grazing production system

Ration code	Nature of ration	Dairy ration ingredients															Total Ration (Kg/ cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MG	[11]MB	[12]CSC	[13]SBC	[14]SL	[15]DCP			
MU20Z16	DM basis (kg)	5.89	0.74					0.74				7.58	2.59		0.05	0.13	17.70	398.93	42:58
	As fed basis (kg)	37.99	0.87					3.30				8.42	2.81		0.05	0.13	53.57		
MU20Z17	DM basis (kg)	5.89	0.74				0.74					6.74	2.31		0.05	0.13	16.58	367.40	44:56
	As fed basis (kg)	37.99	0.87				3.36					7.49	2.51		0.05	0.13	52.39		
MU20Z18	DM basis (kg)	5.89	0.74			0.74						7.76	2.65		0.05	0.14	19.95	418.21	41:59
	As fed basis (kg)	37.99	0.87			7.15						8.62	2.88		0.05	0.14	57.69		
MU20Z19	DM basis (kg)	6.26			6.10							0.12		2.87	0.08		15.42	269.56	80:20
	As fed basis (kg)	40.38			7.62							0.13		3.18	0.08		51.39		
MU20Z20	DM basis (kg)	5.89			0.74			0.74				8.37	2.86		0.06	0.15	18.79	426.01	39:61
	As fed basis (kg)	37.99			0.92			3.30				9.30	3.11		0.06	0.15	54.82		
MU20Z21	DM basis (kg)	5.89			0.74		0.74					7.54	2.58		0.05	0.15	17.67	394.50	42:58
	As fed basis (kg)	37.99			0.92		3.36					8.37	2.80		0.05	0.15	53.65		
MU20Z22	DM basis (kg)	5.89			0.74	0.74					1.47	6.21	2.62		0.07	0.11	17.84	400.90	41:59
	As fed basis (kg)	37.99			0.92	7.15					1.61	6.90	2.85		0.07	0.11	57.60		
MU20Z23	DM basis (kg)	4.19			3.17						2.89	0.54		2.14	0.12		13.05	268.98	56:44
	As fed basis (kg)	27.06			3.96						3.18	0.59		2.38	1.12		37.29		

[1]Young Napier grass, [2]Rhodes grass hay, [3]Green maize stalk, [4]Maize stover, [5]Sweet potato vines, [6]Calliandra dry leaves, [7]Desmodium, [8]Lucerne hay, [9]wheat bran, [10]Maize germ, [11]Maize bran, [12]Cotton seed cake, [13]Soya bean cake, [14]stock lime, [15]Di-calcium Phosphate

Table 29. Dairy ration options for producing 25 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Ration code	Nature of ration	Dairy ration ingredients															Total Ration (Kg/ cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MG	[11]MB	[12]CSC	[13]SBC	[14]SL	[15]DCP			
Napier grass based ration																			
MU25Z1	DM basis (kg)	5.08							4.21		4.81	0.38		1.16	0.02		15.67	334.51	59:41
	As fed basis (kg)	32.78							4.95		5.28	0.42		1.29	0.02		44.76		
Green maize stalk based ration																			
MU25Z2	DM basis (kg)			2.01					4.69	6.76			1.31		0.49		15.26	318.10	44:56
	As fed basis (kg)			6.96					5.25	7.72			1.45		0.49		21.86		
Lucerne hay based ration																			
MU25Z3	DM basis (kg)								7.36		3.32	4.69		0.85		0.10	16.33	427.36	45:55
	As fed basis (kg)								8.66		3.65	5.21		0.95		0.11	18.57		
Rhodes grass hay based rations																			
MU25Z4	DM basis (kg)		7.36									7.34		2.88	0.09	0.11	17.78	499.79	41:59
	As fed basis (kg)		8.66									8.15		3.20	0.09	0.12	20.22		
MU25Z5	DM basis (kg)		6.62					0.74				8.04		2.73	0.08	0.12	18.32	498.03	40:60
	As fed basis (kg)		7.79					3.30				8.93		3.03	0.08	0.12	23.26		
MU25Z6	DM basis (kg)		7.36									7.34		2.88	0.09	0.11	17.78	499.79	41:59
	As fed basis (kg)		8.66									8.15		3.20	0.09	0.12	20.22		
MU25Z7	DM basis (kg)		6.62			0.74						7.32		2.65	0.07	0.11	17.51	486.88	42:58
	As fed basis (kg)		7.79			7.15						8.13		2.95	0.07	0.11	26.20		

Table 29. Dairy ration options for producing 25 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system																				
Ration code	Nature of ration	Dairy ration ingredients															Total Ration (Kg/ cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MG	[11]MB	[12]CSC	[13]SBC	[14]SL	[15]DCP			
MU25Z8	DM basis (kg)		2.01						4.69	7.15			1.32		0.55		15.71	350.11	43:57
	As fed basis (kg)		2.37						5.25	8.16			1.46		0.55		17.78		
Maize stover based rations																			
MU25Z9	DM basis (kg)				7.96						4.33			3.29	0.15	0.00	15.73	358.14	51:49
	As fed basis (kg)				9.94						4.76			3.65	0.15	0.00	18.51		
MU25Z10	DM basis (kg)				2.01				4.69	6.75			1.63		0.51		15.59	333.28	43:57
	As fed basis (kg)				2.16				5.25	7.71			1.80		0.51		17.43		
Forage mixtures based rations																			
MU2511	DM basis (kg)	5.47	1.90									6.90		2.31	0.10	0.10	16.78	397.41	44:56
	As fed basis (kg)	35.26	2.23									7.67		2.57	0.10	0.11	47.93		
MU2512	DM basis (kg)	4.56	0.34					2.46			1.17	7.12	2.82		0.06	0.13	18.66	438.06	39:61
	As fed basis (kg)	29.41	0.40					11.04			1.28	7.91	3.07		0.06	0.14	53.30		
MU25Z13	DM basis (kg)	5.07	1.19				1.10					8.13		2.01	0.08	0.14	17.72	406.38	42:58
	As fed basis (kg)	32.69	1.40				5.04					9.03		2.24	0.08	0.14	50.62		
MU25Z14	DM basis (kg)	4.26	2.36			0.74						6.98		2.21	0.08	0.10	16.73	407.08	44:56
	As fed basis (kg)	27.48	2.78			7.15						7.75		2.45	0.08	0.11	47.81		

Table 29. Dairy ration options for producing 25 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Ration code	Nature of ration	Dairy ration ingredients															Total Ration (Kg/ cow/ day)	Cost (KES/ cow/ day)	Forage : Concentrate ratio
		[1]YNG	[2]RGH	[3]GMS	[4]MS	[5]SPV	[6]CL	[7]D	[8]LH	[9]WB	[10]MG	[11]MB	[12]CSC	[13]SBC	[14]SL	[15]DCP			
MU25Z15	DM basis (kg)	5.41			5.98							0.39		5.09	0.13		17.00	442.17	67:33
	As fed basis (kg)	34.87			7.48							0.43		5.66	0.13		48.57		
MU25Z16	DM basis (kg)	5.33			4.27			0.51				4.31		3.01	0.10	0.08	17.60	377.77	57:43
	As fed basis (kg)	34.37			5.34			2.27				4.79		3.35	0.10	0.08	50.29		
MU25Z17	DM basis (kg)	5.33			4.24		0.50					4.41		2.95	0.10	0.09	17.62	379.74	57:43
	As fed basis (kg)	34.37			5.30		2.30					4.89		3.28	0.10	0.10	50.34		
MU25Z18	DM basis (kg)	4.63			5.66		0.54					3.01		3.26	0.10	0.07	17.26	374.67	63:37
	As fed basis (kg)	29.85			7.08		5.26					3.34		3.62	0.10	0.07	49.31		
MU25Z19	DM basis (kg)	4.89			2.87						3.99	0.97		2.28	0.15		15.14	315.29	51:49
	As fed basis (kg)	31.52			3.58						4.38	1.08		2.53	0.15		43.24		

[1]Young Napier grass, [2]Rhodes grass hay, [3]Green maize stalk, [4]Maize stover, [5]Sweet potato vines, [6]Calliandra dry leaves, [7]Desmodium, [8]Lucerne hay, [9]wheat bran, [10]Maize germ, [11]Maize bran, [12]Cotton seed cake, [13]Soya bean cake, [14]stock lime, [15]Di-calcium Phosphate

2.4 Expected nutrient composition and intake of formulated dairy rations

The expected nutrient composition and intake of some dairy rations formulated are as indicated in Tables 30a-33b. The rations have been coded as follows.

Table 30a. Expected quality (g DM/100 g as fed) of formulated dairy ration options for producing 10 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Dairy ration number	[1]DM	[2]NEL (Mcal/ kg DM)	[3]TDN	[4]CP	[5]RUP	[6]RDP	[7]CF	[8]ADF	[9]NDF	[10]Fat	[11]Ash	[12]NPN	[13]Ca	[14]P
Napier grass based rations														
MU10Z1	25.00	1.50	65.62	12.00	15.75	27.33	23.97	23.41	51.78	3.44	11.62	0.00	0.43	0.28
MU10Z2	25.00	1.22	53.58	12.00	12.56	22.16	23.95	25.52	53.40	3.02	14.50	0.00	1.74	0.28
MU10Z3	25.00	1.23	54.20	12.00	11.96	21.10	21.74	27.46	52.48	2.87	11.25	0.00	0.46	0.28
MU10Z4	25.00	1.52	66.00	12.00	11.99	24.46	20.52	22.49	51.49	3.83	10.36	0.00	0.67	0.28
MU10Z5	25.00	1.33	59.51	12.00	16.13	29.27	28.05	27.12	50.35	2.87	17.73	0.00	2.40	0.31
Rhodes grass hay based rations														
MU10Z6	87.22	1.32	57.68	12.00	2.30	2.30	29.50	25.03	50.24	3.48	7.78	0.00	0.43	0.28
MU10Z7	56.46	1.08	48.10	12.00	0.09	0.51	27.59	27.57	55.45	3.34	7.75	0.00	0.50	0.28
MU10Z8	59.35	1.13	50.15	12.00	0.00	0.00	23.48	27.08	52.25	3.12	7.68	0.00	0.51	0.28
MU10Z9	43.66	1.36	59.67	12.00	3.01	8.84	28.00	25.76	50.94	3.27	7.98	0.00	0.51	0.29
MU10Z110	85.46	1.65	52.70	12.00	2.00	5.10	34.19	32.29	53.25	1.90	8.76	0.00	0.86	0.28
MU10Z111	86.93	1.30	34.85	12.00	1.04	2.67	26.27	30.68	57.09	1.63	10.31	0.00	0.76	0.51
Maize stover based rations														
MU10Z112	82.23	1.33	57.81	12.00	1.03	5.83	30.02	35.88	59.17	2.44	7.03	0.08	0.49	0.31
MU10Z113	90.12	1.34	37.27	12.00	1.56	3.98	28.82	33.88	56.70	1.55	7.78	0.04	0.73	0.43
Forage mixtures based rations														
MU10Z14	25.00	1.43	62.60	12.00	16.30	27.84	28.76	25.63	51.71	2.77	12.71	0.00	0.47	0.31
MU10Z15	25.00	1.28	56.28	12.00	13.60	23.72	28.42	27.36	54.71	2.66	11.92	0.00	0.43	0.28
MU10Z16	25.00	1.27	56.28	12.00	13.22	23.32	26.56	27.70	53.04	2.41	12.09	0.00	0.43	0.28
MU10Z17	25.00	1.44	63.29	12.00	10.99	23.81	26.52	25.72	51.90	2.99	10.52	0.00	0.49	0.31
MU10Z18	25.00	1.45	63.22	12.00	16.77	28.27	28.41	27.64	53.97	2.86	12.24	0.00	0.46	0.30
MU10Z19	25.00	1.33	58.08	12.00	15.10	25.57	29.41	29.88	56.54	2.61	11.85	0.02	0.43	0.28
MU10Z20	25.00	1.14	50.06	12.00	12.53	21.55	29.10	34.86	57.82	1.65	12.04	0.03	0.48	0.28
MU10Z21	25.00	1.46	63.83	12.00	11.84	24.60	26.74	29.66	55.86	3.02	9.88	0.03	0.49	0.31
MU10Z22	25.00	1.40	61.63	12.00	15.43	29.20	30.87	30.88	55.20	2.22	12.98	0.03	0.52	0.33
MU10Z23	25.00	1.45	47.43	12.00	14.32	25.43	27.17	26.99	52.09	1.64	13.63	0.00	0.70	0.47

[1]Dry matter, [2]Net energy of lactation, [3]Total digestible nutrients, [4]Crude protein, [5]rumen undegradable protein, [6]Rumen degradable protein, [7]Crude fibre, [8]Acid detergent fibre, [9]Neutral detergent fibre, [10]Fat, [11]Ash, [12]Non-protein-nitrogen, [13]Calcium, and [14]Phosphorus

Table 30b. Expected nutrient intake (kg/cow/day) of formulated dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Dairy ration number	[1]DMI	[2]NELI (Mcal/cow/day)	[3]TDNI	[4]CPI	[5]RUPI	[6]RDPI	[7]CFI	[8]ADFI	[9]NDFI	[10]FatI	[11]AshI	[12]NPNI	[13]CaI	[14]PI
Napier grass based rations														
MU10Z1	13.60	20.34	8.93	1.63	2.14	3.72	3.26	3.18	7.04	0.47	1.58	0.00	0.06	0.04
MU10Z2	12.35	15.01	6.62	1.48	1.55	2.74	2.96	3.15	6.59	0.37	1.79	0.00	0.22	0.04
MU10Z3	12.20	15.01	6.61	1.63	1.46	2.57	2.65	3.35	6.40	0.35	1.37	0.00	0.06	0.03
MU10Z4	15.26	23.18	10.19	1.83	1.83	3.73	3.13	3.43	7.86	0.58	1.58	0.00	0.10	0.04
MU10Z5	9.60	12.76	5.71	1.15	1.55	2.81	2.69	2.60	4.83	0.28	1.70	0.00	0.23	0.03
Rhodes grass hay based rations														
MU10Z6	12.58	16.61	7.25	1.51	0.29	0.29	3.71	3.15	6.32	0.44	0.80	0.00	0.05	0.04
MU10Z7	11.79	12.76	5.67	1.42	0.01	0.06	3.25	3.25	6.54	0.39	0.91	0.00	0.06	0.03
MU10Z8	13.29	15.01	6.66	1.59	0.00	0.00	3.12	3.60	6.94	0.41	1.02	0.00	0.07	0.04
MU10Z9	11.04	15.01	6.59	1.33	0.33	0.98	3.09	2.84	5.62	0.36	0.88	0.00	0.06	0.03
MU10Z10	10.95	12.76	5.77	1.31	0.22	0.56	3.74	3.54	5.83	0.21	0.96	0.00	0.10	0.03
MU10Z11	9.68	12.61	3.37	1.16	0.10	0.26	2.54	2.97	5.53	0.16	1.00	0.00	0.07	0.05
Maize stover based rations														
MU10Z12	9.61	12.76	5.56	1.15	0.10	0.56	2.89	3.45	5.69	0.24	0.68	0.01	0.05	0.03
MU10Z13	9.39	12.61	3.50	1.13	0.15	0.37	2.71	3.18	5.32	0.15	0.73	0.00	0.07	0.04
Forage mixtures based rations														
MU10Z14	10.51	15.01	6.58	1.26	1.71	2.93	3.02	2.69	5.43	0.29	1.34	0.00	0.05	0.03
MU10Z15	11.76	15.01	6.62	1.41	1.60	2.79	3.34	3.22	6.43	0.31	1.40	0.00	0.05	0.03
MU10Z16	11.80	15.01	6.64	1.42	1.56	2.75	3.13	3.27	6.26	0.28	1.43	0.00	0.05	0.03
MU10Z17	10.43	15.01	6.60	1.25	1.15	2.48	2.77	2.68	5.42	0.31	1.10	0.00	0.05	0.03
MU10Z18	10.67	15.45	6.74	1.28	1.79	3.02	3.03	2.95	5.76	0.31	1.31	0.00	0.05	0.03
MU10Z19	11.31	15.01	6.57	1.36	1.71	2.89	3.33	3.38	6.39	0.30	1.34	0.00	0.05	0.03
MU10Z20	13.22	15.01	6.62	1.59	1.66	2.85	3.85	4.61	7.65	0.22	1.59	0.00	0.06	0.04
MU10Z21	10.28	15.03	6.56	1.23	1.22	2.53	2.75	3.05	5.74	0.31	1.02	0.00	0.05	0.03
MU10Z22	9.10	12.76	5.61	1.09	1.40	2.66	2.81	2.81	5.02	0.20	1.18	0.00	0.05	0.03
MU10Z23	8.67	12.61	4.11	1.04	1.24	2.21	2.36	2.35	4.52	0.14	1.18	0.00	0.06	0.04

[1]Dry matter intake, [2]Net energy of lactation intake, [3]Total digestible nutrient intake, [4]Crude protein intake, [5]rumen undegradable protein intake, [6]Rumen degradable protein intake, [7]Crude fibre intake, [8]Acid detergent fibre intake, [9]Neutral detergent fibre intake, [10]Fat intake, [11]Ash intake, [12]Non-protein-nitrogen intake, [13]Calcium intake, and [14]Phosphorus intake

Table 31a. Expected quality (g DM/100 g as fed) of formulated dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Dairy ration number	[1]DM	[2]NEL (Mcal/kg DM)	[3]TDN	[4]CP	[5]RUP	[6]RDP	[7]CF	[8]ADF	[9]NDF	[10]Fat	[11]Ash	[12]NPN	[13]Ca	[14]P
Napier grass based rations														
MU15Z1	30.00	1.55	67.07	15.00	14.90	23.83	22.87	22.22	48.44	5.00	11.01	0.00	0.53	0.34
MU15Z2	30.00	1.35	59.26	15.00	9.56	18.32	21.53	23.89	51.65	5.00	10.39	0.00	0.53	0.34
MU15Z3	30.00	1.32	57.08	15.00	11.05	18.03	20.35	25.31	49.85	3.80	10.17	0.00	0.53	0.34
MU15Z4	30.00	1.55	66.83	15.00	13.53	22.82	21.25	21.90	48.25	4.56	9.90	0.00	0.53	0.34
MU15Z5	30.00	1.46	64.81	15.00	13.04	25.23	26.04	26.41	49.98	4.27	11.53	0.00	0.56	0.36
Rhodes grass hay based rations														
MU15Z6	85.88	1.25	54.03	15.00	1.12	6.32	32.81	26.02	44.37	1.92	9.67	0.00	0.56	0.38
MU15Z7	59.53	1.19	52.09	15.00	0.58	3.28	24.78	25.27	50.68	4.21	7.96	0.00	0.53	0.34
MU15Z8	67.43	1.26	54.58	15.00	0.64	3.65	22.22	24.26	46.87	3.36	7.69	0.00	0.53	0.34
MU15Z9	56.17	1.33	57.65	15.00	1.82	9.33	28.80	25.00	45.35	2.55	8.77	0.00	0.53	0.34
MU15Z10	87.18	1.34	61.13	15.00	2.71	6.94	25.26	29.37	52.03	5.00	7.53	0.00	0.92	0.34
MU15Z11	88.03	1.40	29.93	15.00	1.97	5.02	22.49	26.24	48.88	1.80	9.30	0.00	0.91	0.61
Maize stover based rations														
MU15Z12	83.52	1.41	60.71	15.00	1.36	7.72	26.29	31.86	52.58	3.49	7.25	0.06	0.54	0.35
MU15Z13	89.05	1.42	30.68	15.00	2.12	5.43	23.33	27.29	48.83	1.78	8.39	0.01	0.89	0.58
Forage mixtures based rations														
MU15Z14	30.00	1.47	63.59	15.00	12.34	24.65	24.29	22.86	46.49	3.06	11.40	0.00	0.53	0.34
MU15Z15	30.93	1.27	54.56	15.00	10.83	17.15	24.85	26.07	52.56	3.87	10.05	0.00	0.53	0.34
MU15Z16	30.00	1.34	57.75	15.00	12.26	19.67	23.27	25.71	49.48	3.61	10.77	0.00	0.53	0.34
MU15Z17	30.89	1.54	66.18	15.00	12.27	21.38	21.89	22.36	48.25	4.48	9.55	0.00	0.53	0.34
MU15Z18	32.34	1.55	66.80	15.00	13.77	21.72	22.39	22.21	48.54	5.00	10.38	0.00	0.53	0.34
MU15Z19	35.86	1.45	62.01	15.00	11.08	16.99	22.18	23.71	50.38	4.54	9.17	0.01	0.53	0.34
MU15Z20	33.78	1.43	61.29	15.00	11.63	18.13	21.92	24.62	49.72	4.19	9.71	0.01	0.53	0.34
MU15Z21	31.49	1.55	67.09	15.00	12.06	20.89	21.77	23.05	49.29	5.00	9.49	0.01	0.53	0.34
MU15Z22	30.00	1.47	64.16	15.00	12.39	25.45	26.24	27.23	50.17	3.53	11.77	0.03	0.56	0.36
MU15Z23	49.96	1.45	33.66	15.00	5.92	11.77	22.64	25.02	47.28	1.82	10.26	0.00	0.89	0.60

[1]Dry matter, [2]Net energy of lactation, [3]Total digestible nutrients, [4]Crude protein, [5]rumen undegradable protein, [6]Rumen degradable protein, [7]Crude fibre, [8]Acid detergent fibre, [9]Neutral detergent fibre, [10]Fat, [11]Ash, [12]Non-protein-nitrogen, [13]Calcium, and [14]Phosphorus

Table 31b. Expected nutrient intake (kg/cow/day) of formulated dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Dairy ration number	[1]DMI	[2]NELI (Mcal/cow/day)	[3]TDNI	[4]CPI	[5]RUPI	[6]RDPI	[7]CFI	[8]ADFI	[9]NDFI	[10]FatI	[11]AshI	[12]NPNI	[13]CaI	[14]PI
Napier grass based rations														
MU15Z1	17.64	27.36	11.83	2.65	2.63	4.20	4.04	3.92	8.55	0.88	1.94	0.00	0.09	0.06
MU15Z2	15.71	21.13	9.31	2.36	1.50	2.88	3.38	3.75	8.12	0.79	1.63	0.00	0.08	0.05
MU15Z3	15.79	20.82	9.01	2.37	1.75	2.85	3.21	4.00	7.87	0.60	1.61	0.00	0.08	0.05
MU15Z4	18.73	29.11	12.52	2.81	2.54	4.27	3.98	4.10	9.04	0.85	1.86	0.00	0.10	0.06
MU15Z5	11.13	16.20	7.21	1.67	1.45	2.81	2.90	2.94	5.56	0.48	1.28	0.00	0.06	0.04
Rhode grass hay based rations														
MU15Z6	14.77	18.45	7.98	2.22	0.17	0.93	4.85	3.84	6.55	0.28	1.43	0.00	0.08	0.06
MU15Z7	13.65	16.20	7.11	2.05	0.09	0.53	3.48	3.68	7.55	0.56	1.11	0.00	0.08	0.05
MU15Z8	14.69	18.45	8.02	2.20	0.08	0.45	3.38	3.45	6.92	0.57	1.09	0.00	0.07	0.05
MU15Z9	13.87	18.45	7.99	2.08	0.25	1.29	3.99	3.47	6.29	0.35	1.22	0.00	0.07	0.05
MU15Z10	12.06	16.20	7.37	1.81	0.33	0.84	3.05	3.54	6.27	0.60	0.91	0.00	0.33	0.04
MU15Z11	11.45	16.04	3.43	1.72	0.23	0.58	2.57	3.00	5.59	0.21	1.07	0.00	0.10	0.07
Maize stover based rations														
MU15Z12	11.53	16.20	7.00	1.73	0.16	0.89	3.03	3.67	6.18	0.40	0.84	0.01	0.06	0.04
MU15Z13	11.32	16.04	3.47	1.70	0.24	0.62	2.64	3.09	5.53	0.20	0.95	0.00	0.10	0.07
Forage mixtures based rations														
MU15Z14	12.57	18.45	7.99	1.89	1.55	3.10	3.05	2.87	5.84	0.39	1.43	0.00	0.07	0.04
MU15Z15	14.58	18.45	7.95	2.19	1.58	2.50	3.62	3.80	7.66	0.56	1.47	0.00	0.08	0.05
MU15Z16	13.79	18.45	7.96	2.07	1.69	2.71	3.21	3.55	6.82	0.50	1.49	0.00	0.07	0.05
MU15Z17	17.40	26.78	11.52	2.61	2.13	3.72	3.81	3.89	8.40	0.78	1.66	0.00	0.09	0.06
MU15Z18	18.82	29.13	12.57	2.82	2.59	4.09	4.21	4.18	9.14	0.94	1.95	0.00	0.10	0.06
MU15Z19	18.66	26.97	11.57	2.80	2.07	3.17	4.14	4.43	9.40	0.85	1.71	0.00	0.10	0.06
MU15Z20	16.98	24.21	10.41	2.55	1.98	3.08	3.72	4.18	8.44	0.71	1.65	0.00	0.09	0.06
MU15Z21	17.96	27.91	12.05	2.69	2.69	3.75	3.91	4.14	8.85	0.90	1.71	0.00	0.10	0.06
MU15Z22	11.00	16.20	7.06	1.65	1.36	2.80	2.89	3.00	5.52	0.39	1.30	0.00	0.06	0.04
MU15Z23	11.05	16.04	3.72	1.66	0.65	1.30	2.50	2.77	5.23	0.20	1.14	0.00	0.10	0.07

[1]Dry matter intake, [2]Net energy of lactation intake, [3]Total digestible nutrient intake, [4]Crude protein intake, [5]rumen undegradable protein intake, [6]Rumen degradable protein intake, [7]Crude fibre intake, [8]Acid detergent fibre intake, [9]Neutral detergent fibre intake, [10]Fat intake, [11]Ash intake, [12]Non-protein-nitrogen intake, [13]Calcium intake, and [14]Phosphorus intake

Table 32a. Expected quality (g DM/100 g as fed) of formulated dairy ration options for producing 20 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system														
Dairy ration number	**[1]DM**	**[2]NEL (Mcal/kg DM)**	**[3]TDN**	**[4]CP**	**[5]RUP**	**[6]RDP**	**[7]CF**	**[8]ADF**	**[9]NDF**	**[10]Fat**	**[11]Ash**	**[12]NPN**	**[13]Ca**	**[14]P**
Napier grass based rations														
MU20Z1	30.00	1.55	67.07	15.00	14.90	23.83	22.87	22.22	48.44	5.00	11.00	0.00	0.53	0.34
MU20Z2	30.00	1.48	63.41	15.00	14.03	22.36	22.70	23.02	49.38	4.32	10.46	0.00	0.53	0.34
MU20Z3	30.00	1.47	63.35	15.00	13.85	22.17	21.93	23.18	48.70	4.21	10.53	0.00	0.53	0.34
MU20Z4	30.00	1.55	66.83	15.00	13.54	22.82	21.25	21.89	48.25	4.56	9.90	0.00	0.53	0.34
MU20Z5	35.00	1.47	65.60	16.00	10.76	21.77	24.49	25.55	48.66	5.00	10.77	0.00	0.60	0.38
Green maize stalk based ration														
MU20Z6	67.46	1.48	33.99	16.00	4.00	6.63	20.92	24.77	46.60	2.52	9.69	0.00	0.98	0.66
Lucerne hay based ration														
MU20Z7	87.60	1.39	62.22	16.00	2.60	7.45	22.66	27.10	49.60	5.00	7.22	0.00	0.89	0.38
Rhodes grass hay based rations														
MU20Z8	87.64	1.40	60.35	15.00	0.88	4.97	23.37	21.66	44.95	3.60	7.49	0.00	0.53	0.34
MU20Z9	77.52	1.35	58.37	15.00	0.78	4.43	22.68	22.20	46.49	3.73	7.31	0.00	0.53	0.34
MU20Z10	72.89	1.35	58.36	15.00	3.35	3.35	23.15	23.80	48.19	5.00	7.61	0.00	0.53	0.34
MU20Z11	64.57	1.42	61.45	15.00	1.39	7.21	22.56	21.82	45.44	3.69	7.38	0.00	0.53	0.34
MU20Z12	88.37	1.44	28.77	16.00	2.85	5.63	20.85	24.48	46.54	2.21	10.09	0.00	1.01	0.67
Maize stover based rations														
MU20Z13	84.55	1.45	62.88	16.00	1.39	7.85	24.05	29.23	51.19	4.50	7.22	0.05	0.60	0.38
MU20Z14	89.17	1.45	30.35	16.00	3.21	6.00	21.78	25.67	46.94	2.29	9.51	0.01	0.99	0.66
Forage mixtures based rations														
MU20Z15	33.32	1.54	66.48	15.00	13.28	20.87	22.61	22.01	48.21	5.00	10.32	0.00	0.53	0.34
MU20Z16	33.05	1.47	63.05	15.00	12.55	19.67	22.66	22.87	49.16	4.42	9.92	0.00	0.53	0.34
MU20Z17	31.65	1.46	62.63	15.00	13.02	20.62	22.51	24.43	48.63	4.17	10.34	0.00	0.53	0.34
MU20Z18	31.12	1.54	66.23	15.00	12.96	21.77	21.91	22.18	48.19	4.50	9.81	0.00	0.53	0.34
MU20Z19	30.00	1.42	61.02	15.10	12.54	26.69	28.75	30.48	51.21	1.91	11.54	0.04	0.53	0.34
MU20Z20	34.28	1.48	63.46	15.00	12.14	18.85	22.10	23.08	49.61	4.54	9.54	0.00	0.53	0.34
MU20Z21	32.94	1.47	63.10	15.00	12.56	19.69	21.93	23.63	49.13	4.31	9.91	0.00	0.53	0.34
MU20Z22	30.97	1.55	67.09	15.00	13.00	21.87	22.87	22.78	49.02	5.00	10.00	0.00	0.53	0.34
MU20Z23	35.00	1.51	65.58	16.00	10.03	21.73	23.88	25.51	48.49	4.47	10.94	0.02	0.60	0.38

[1]Dry matter, [2]Net energy of lactation, [3]Total digestible nutrients, [4]Crude protein, [5]rumen undegradable protein, [6]Rumen degradable protein, [7]Crude fibre, [8]Acid detergent fibre, [9]Neutral detergent fibre, [10]Fat, [11]Ash, [12]Non-protein-nitrogen, [13]Calcium, and [14]Phosphorus

Table 32b. Expected nutrient intake (kg/cow/day) of formulated dairy ration options for producing 20 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Dairy ration number	[1]DMI	[2]NELI (Mcal/cow/day)	[3]TDNI	[4]CPI	[5]RUPI	[6]RDPI	[7]CFI	[8]ADFI	[9]NDFI	[10]FatI	[11]AshI	[12]NPNI	[13]CaI	[14]PI
Napier grass based rations														
MU20Z1	17.64	27.36	11.83	2.65	2.63	4.20	4.04	3.92	8.55	0.88	1.94	0.00	0.09	0.06
MU20Z2	17.00	25.08	10.78	2.55	2.39	3.80	3.86	3.91	8.40	0.73	1.78	0.00	0.09	0.06
MU20Z3	17.03	25.07	10.79	2.56	2.36	3.78	3.74	3.95	8.30	0.72	1.79	0.00	0.09	0.06
MU20Z4	18.73	29.11	12.52	2.81	2.54	4.27	3.98	4.10	9.04	0.85	1.86	0.00	0.10	0.06
MU20Z5	13.33	19.64	8.74	2.13	1.43	2.90	3.26	3.41	6.49	0.67	1.44	0.00	0.08	0.05
Green maize stalk based ration														
MU20Z6	13.14	19.48	4.47	2.10	0.53	0.87	2.75	3.26	6.12	0.33	1.27	0.00	0.13	0.09
Lucerne hay based ration														
MU20Z7	14.16	19.64	8.81	2.27	0.37	1.05	3.21	3.84	7.02	0.71	1.02	0.00	0.13	0.05
Rhodes grass hay based rations														
MU20Z8	15.69	21.89	9.47	2.35	0.14	0.78	3.67	3.40	7.05	0.57	1.18	0.00	0.08	0.05
MU20Z9	16.24	21.89	9.48	2.44	0.13	0.72	3.68	3.61	7.55	0.61	1.19	0.00	0.09	0.06
MU20Z10	18.66	25.17	10.89	2.80	0.63	0.63	4.32	4.44	8.99	0.93	1.42	0.00	0.10	0.06
MU20Z11	15.43	21.89	9.48	2.31	0.21	1.11	3.48	3.37	7.01	0.57	1.14	0.00	0.08	0.05
MU20Z12	13.51	19.48	3.89	2.16	0.39	0.76	2.82	3.31	6.29	0.30	1.36	0.00	0.14	0.09
Maize stover based rations														
MU20Z13	13.54	19.64	8.51	2.17	0.19	1.06	3.26	3.96	6.93	0.61	1.02	0.01	0.08	0.05
MU20Z14	13.43	19.48	4.08	2.15	0.43	0.81	2.92	3.45	6.30	0.31	1.28	0.00	0.13	0.09
Forage mixtures based rations														
MU20Z15	18.69	28.78	12.42	2.80	2.48	3.90	4.23	4.11	9.01	0.93	1.93	0.00	0.10	0.06
MU20Z16	17.70	25.98	11.16	2.66	2.22	3.48	4.01	4.05	8.70	0.78	1.76	0.00	0.09	0.06
MU20Z17	16.58	24.14	10.39	2.49	2.16	3.42	3.73	3.89	8.06	0.69	1.72	0.00	0.09	0.06
MU20Z18	17.95	27.66	11.89	2.69	2.33	3.91	3.93	3.98	8.65	0.81	1.76	0.00	0.10	0.06
MU20Z19	15.42	21.89	9.41	2.33	1.93	4.12	4.43	4.70	7.90	0.30	1.78	0.01	0.08	0.05
MU20Z20	18.79	27.79	11.93	2.82	2.28	3.54	4.15	4.34	9.32	0.85	1.79	0.00	0.10	0.06
MU20Z21	17.67	25.95	11.15	2.65	2.22	3.48	3.88	4.18	8.68	0.76	1.75	0.00	0.09	0.06
MU20Z22	17.84	27.70	11.97	2.68	2.32	3.90	3.90	4.06	8.74	0.89	1.78	0.00	0.10	0.06
MU20Z23	13.05	19.64	8.56	2.09	1.31	2.84	3.12	3.33	6.33	0.58	1.43	0.00	0.08	0.05

[1]Dry matter intake, [2]Net energy of lactation intake, [3]Total digestible nutrient intake, [4]Crude protein intake, [5]rumen undegradable protein intake, [6]Rumen degradable protein intake, [7]Crude fibre intake, [8]Acid detergent fibre intake, [9]Neutral detergent fibre intake, [10]Fat intake, [11]Ash intake, [12]Non-protein-nitrogen intake, [13]Calcium intake, and [14]Phosphorus intake

Table 33a. Expected quality (g DM/100 g as fed) of formulated dairy ration options for producing 25 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Dairy ration number	[1]DM	[2]NEL (Mcal/kg DM)	[3]TDN	[4]CP	[5]RUP	[6]RDP	[7]CF	[8]ADF	[9]NDF	[10]Fat	[11]Ash	[12]NPN	[13]Ca	[14]P
Napier grass based ration														
MU25Z1	35.00	1.47	65.60	16.00	10.76	21.77	24.49	25.55	48.66	5.00	10.77	0.00	0.60	0.38
Green maize stalk based ration														
MU25Z2	69.80	1.50	30.36	16.00	3.78	6.05	19.55	23.20	45.62	2.61	10.52	0.00	1.06	0.71
Lucerne hay based ration														
MU25Z3	87.91	1.41	62.96	16.00	2.36	7.05	20.97	25.55	48.83	5.00	6.83	0.00	0.83	0.38
Rhodes grass hay based rations														
MU25Z4	87.94	1.43	61.33	16.00	1.02	5.79	21.51	20.63	43.44	3.83	7.48	0.00	0.60	0.38
MU25Z5	78.79	1.38	59.55	16.00	0.94	5.32	20.94	21.13	44.81	3.94	7.33	0.00	0.60	0.38
MU25Z6	87.94	1.43	61.33	16.00	1.02	5.79	21.51	20.63	43.44	3.83	7.48	0.00	0.60	0.38
MU25Z7	66.84	1.45	62.32	16.00	1.47	7.76	20.78	20.76	43.87	3.91	7.38	0.00	0.60	0.38
MU25Z8	88.39	1.46	27.65	16.00	3.20	5.29	19.93	23.55	46.31	2.51	11.21	0.00	1.08	0.72
Maize stover based rations														
MU25Z9	84.97	1.47	63.86	16.00	1.32	3.46	23.35	28.31	50.91	5.00	7.56	0.05	0.60	0.38
MU25Z10	89.43	1.47	29.68	16.00	3.67	5.77	21.12	25.08	46.83	2.61	10.47	0.01	1.05	0.70
Forage mixtures based rations														
MU25Z11	35.00	1.51	65.07	16.00	9.99	21.02	20.43	20.74	44.74	3.73	10.16	0.00	0.60	0.38
MU25Z12	35.00	1.36	58.33	16.00	10.20	15.43	22.00	23.89	50.53	5.00	9.46	0.00	0.60	0.38
MU25Z13	35.00	1.43	61.74	16.00	8.72	18.18	18.76	21.84	45.83	3.78	9.72	0.00	0.60	0.38
MU25Z14	35.00	1.51	65.28	16.00	8.50	19.75	19.90	20.85	44.90	3.83	9.47	0.00	0.60	0.38
MU25Z15	35.00	1.49	62.75	19.58	10.79	26.41	24.32	27.03	44.04	2.46	10.74	0.04	0.60	0.38
MU25Z16	35.00	1.44	61.76	16.00	9.55	21.06	23.20	25.95	48.62	3.04	10.06	0.02	0.60	0.38
MU25Z17	35.00	1.44	61.74	16.00	9.52	20.92	22.74	26.06	48.20	2.99	10.11	0.02	0.60	0.38
MU25Z18	35.00	1.47	62.91	16.00	9.08	21.74	24.03	27.28	48.90	2.80	9.83	0.03	0.60	0.38
MU25Z19	35.00	1.53	66.70	16.00	9.99	21.32	22.83	24.22	48.00	5.00	10.94	0.02	0.60	0.38

[1]Dry matter, [2]Net energy of lactation, [3]Total digestible nutrients, [4]Crude protein, [5]rumen undegradable protein, [6]Rumen degradable protein, [7]Crude fibre, [8]Acid detergent fibre, [9]Neutral detergent fibre, [10]Fat, [11]Ash, [12]Non-protein-nitrogen, [13]Calcium, and [14]Phosphorus

Table 33b. Expected nutrient intake (kg/cow/day) of formulated dairy ration options for producing 25 kg milk/cow/day by a cow weighing 400 kg under zero grazing production system

Dairy ration number	[1]DMI	[2]NELI (Mcal/cow/day)	[3]TDNI	[4]CPI	[5]RUPI	[6]RDPI	[7]CFI	[8]ADFI	[9]NDFI	[10]FatI	[11]AshI	[12]NPNI	[13]CaI	[14]PI
Napier grass based ration														
MU25Z1	15.67	23.08	10.28	2.51	1.69	3.41	3.84	4.00	7.62	0.78	1.69	0.00	0.09	0.06
Green maize stalk based ration														
MU25Z2	15.26	22.92	4.63	2.44	0.58	0.92	2.98	3.54	6.96	0.40	1.61	0.00	0.16	0.11
Lucerne hay based ration														
MU25Z3	16.33	23.08	10.28	2.61	0.39	1.15	3.42	4.17	7.97	0.82	1.12	0.00	0.14	0.06
Rhodes grass hay based rations														
MU25Z4	17.78	25.33	10.90	2.84	0.18	1.03	3.82	3.67	7.72	0.68	1.33	0.00	0.11	0.07
MU25Z5	18.32	25.33	10.91	2.93	0.17	0.98	3.84	3.87	8.21	0.72	1.34	0.00	0.11	0.07
MU25Z6	17.78	25.33	10.90	2.84	0.18	1.03	3.82	3.67	7.72	0.68	1.33	0.00	0.11	0.07
MU25Z7	17.51	25.33	10.91	2.80	0.26	1.36	3.64	3.64	7.68	0.68	1.29	0.00	0.11	0.07
MU25Z8	15.71	22.92	4.35	2.51	0.50	0.83	3.13	3.70	7.28	0.39	1.76	0.00	0.17	0.11
Maize stover based rations														
MU25Z9	15.73	23.08	10.05	2.52	0.21	1.17	3.67	4.45	8.01	0.79	1.19	0.01	0.09	0.06
MU25Z10	15.59	22.92	4.63	2.49	0.57	0.90	3.29	3.91	7.30	0.41	1.63	0.00	163.00	0.11
Forage mixtures based rations														
MU25Z11	16.78	25.33	10.92	2.68	1.68	3.53	3.43	3.48	7.51	0.63	1.71	0.00	0.10	0.06
MU25Z12	18.66	25.33	10.88	2.99	1.90	2.88	4.11	4.46	9.43	0.93	1.76	0.00	0.11	0.07
MU25Z13	17.72	25.33	10.94	2.83	1.55	3.22	3.32	3.87	8.12	0.67	1.72	0.00	0.11	0.07
MU25Z14	16.73	25.33	10.92	2.68	1.42	3.31	3.33	3.49	7.51	0.64	1.58	0.00	0.10	0.06
MU25Z15	17.00	25.33	10.67	3.33	1.83	4.49	4.13	4.60	7.49	0.42	1.83	0.01	0.10	0.07
MU25Z16	17.60	25.33	10.87	2.82	1.68	3.71	4.08	4.57	8.56	0.54	1.77	0.00	0.11	0.07
MU25Z17	17.62	25.33	10.88	2.82	1.68	3.69	4.01	4.59	8.49	0.53	1.78	0.00	0.11	0.07
MU25Z18	17.26	25.33	10.86	2.76	1.57	3.75	4.15	4.71	8.44	0.48	1.70	0.01	0.10	0.07
MU25Z19	15.14	23.08	10.10	2.42	1.51	3.23	3.46	3.67	7.27	0.76	1.86	0.00	0.09	0.06

[1]Dry matter intake, [2]Net energy of lactation intake, [3]Total digestible nutrient intake, [4]Crude protein intake, [5]rumen undegradable protein intake, [6]Rumen degradable protein intake, [7]Crude fibre intake, [8]Acid detergent fibre intake, [9]Neutral detergent fibre intake, [10]Fat intake, [11]Ash intake, [12]Non-protein-nitrogen intake, [13]Calcium intake, and [14]Phosphorus intake

2.5 Required nutrients in formulated rations

The required nutrients in the formulated dairy ration depended on animal information provided (e.g. daily milk yield of 10, 15, 20 and 25 kg per cow weighing 400kg). As expected, nutrient requirements increased with level of production (Table 34).

Table 34. Required nutrient levels for a dairy ration supporting daily milk yield of 10, 15, 20 or 25 kg by cow weighing 400kg under zero grazing

Nutrients	Daily milk yield levels (Kg/cow)			
	10	15	20	25
DM (kg/day)	8.67-15.26	11.00-18.82	13.05-18.80	15.14-18.66
NEL (Mcal/Kg DM)	1.45	1.50	1.57	1.64
NEL (Mcal/day)	14.24	17.68	21.12	24.56
TDN (%)	63.00	67.00	71.00	71.00
TDN (kg/day)	5.92	7.42	8.92	10.42
CP (%)	12.00	15.00	16.00	16.00
CP (kg/day)	1.11	1.53	1.95	2.37
RUP (%)	4.50	5.40	5.70	5.70
RUP (Kg/day)	0.33	0.50	0.68	0.85
RDP (%)	7.90	8.80	9.70	9.70
RDP (Kg/day)	0.70	0.92	1.13	1.35
CF (%)	17.00	17.00	17.00	17.00
ADF (%)	21.00	21.00	21.00	21.00
NDF (%)	28.00	28.00	28.00	28.00
FaT (%)-(Min-Max)	3.00-5.00	3.00-5.00	3.00-5.00	3.00-5.00
NPN (%)- Max	0.50	0.50	0.50	0.50
Ca (%)-(Min-Max)	0.43-2.00	0.53-2.00	0.60-2.00	0.60-2.00
Ca (Kg/day)	0.05	0.06	0.08	0.09
P (%)-(Min-Max)	0.28-1.00	0.34-1.00	0.38-1.00	0.38-1.00
P (Kg/day)	0.03	0.04	0.05	0.06

2.6 Remarks On Formulated Dairy Rations

(1) The major basal forages were Napier grass, Rhodes grass hay and maize stovers.

(2) The major forage supplements were sweet potato vines, calliandra, and green leaf desmodium. Lucerne hay was included in dairy rations since it is more nutritious than fodder trees and does not contain anti-nutritive factors

(3) Among the commercial concentrates and minerals included in the feed list, maize bran, maize germ, soya bean meal cake, cotton seed cake, stock lime and Di-calcium phosphate were selected for formulation by the software.

(4) All the feed resources were available for feeding dairy cattle during the wet and dry seasons

(5) A total of 88 rations were developed to produce 10, 15, 20 or 25 kg milk per cow per day.

(6) The minimum forage: concentrate ratio of 39: 61 was comparable to the recommended minimum ration of 40: 60. The highest forage: concentrate ration was 91: 9

(7) Low forage: concentrate ratios were associated with either high milk yields or poor quality basal forages and vice versa.

(8) The lowest costs of formulated dairy rations to produce daily milk levels of 10, 15, 20 and 25 Kg were KES 90.61, 186.89, 268.98 and 315.29 respectively which implies that the average cost of the formulated rations per Kg of milk was KES 12.31 for the dairy ration against price of milk in the County of KES 26.0. Hence, the percentage of feed cost against price of milk was 47.4 per cent.

(9) High costs of dairy rations were associated with high milk yields, low forage: concentrate ratios, low levels of forage supplements, high levels of Rhodes grass hay and vice versa.

(10) Use of forage mixtures based rations (e.g. Napier grass mixed with maize stover) were less expensive when compared to other rations.

(11) Inclusion of fodder trees and legumes significantly reduced the cost of the dairy rations formulated.
Soya bean meal was superior supplement than cotton seed cake based on the quality and cost particularly for high yielding cows.

(12) All the formulated dairy rations met nutrient requirements for the intended level of milk yield

3.0 WAY FORWARD

On-station feeding trials will be conducted to evaluate some of the formulated least-cost dairy rations. The evaluation will involve the determinations of the quality, digestibility, and feed conversion efficiency of the dairy rations as well as their milk yield responses and costs when fed to dairy cattle. The promising dairy rations will be validated on-farm and the best ones recommended and promoted for large scale adoption at farm level in Murang'a County and other Eastern Africa regions with similar climatic conditions.

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