KENYA AGRICULTURAL RESEARCH INSTITUTE

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TOTAL MIXED RATIONS FOR DAIRY CATTLE IN MACHAKOS COUNTY

A Technical Manual for Dairy Extension Workers and Farmer

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
HIV	Human Immuno-deficiency Virus
KARI	Kenya Agricultural Research Institute
KES	Kenya Shillings
Kg	Kilogramme
KIHBS	Kenya Integrated Household Budget Survey
km	Kilometre
LM	Lower Midlands
Max	Maximum
Mcal	Megacalories
Min	Minimum
mm	Millimetre
MA10Z1	Machakos 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
TB	Tuberculosis
TDN	Total Digestible Nutrients
UH	Upper Highlands
UM	Upper Midlands
UMB	Unidentified Mineral Block
UMS	Unidentified Mineral Salt
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 Machakos 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

Machakos County is located in Eastern Kenya and borders Murang'a, Kiambu, Nairobi, Kajiado, Makueni, Kitui and Embu Counties (Figure 1).

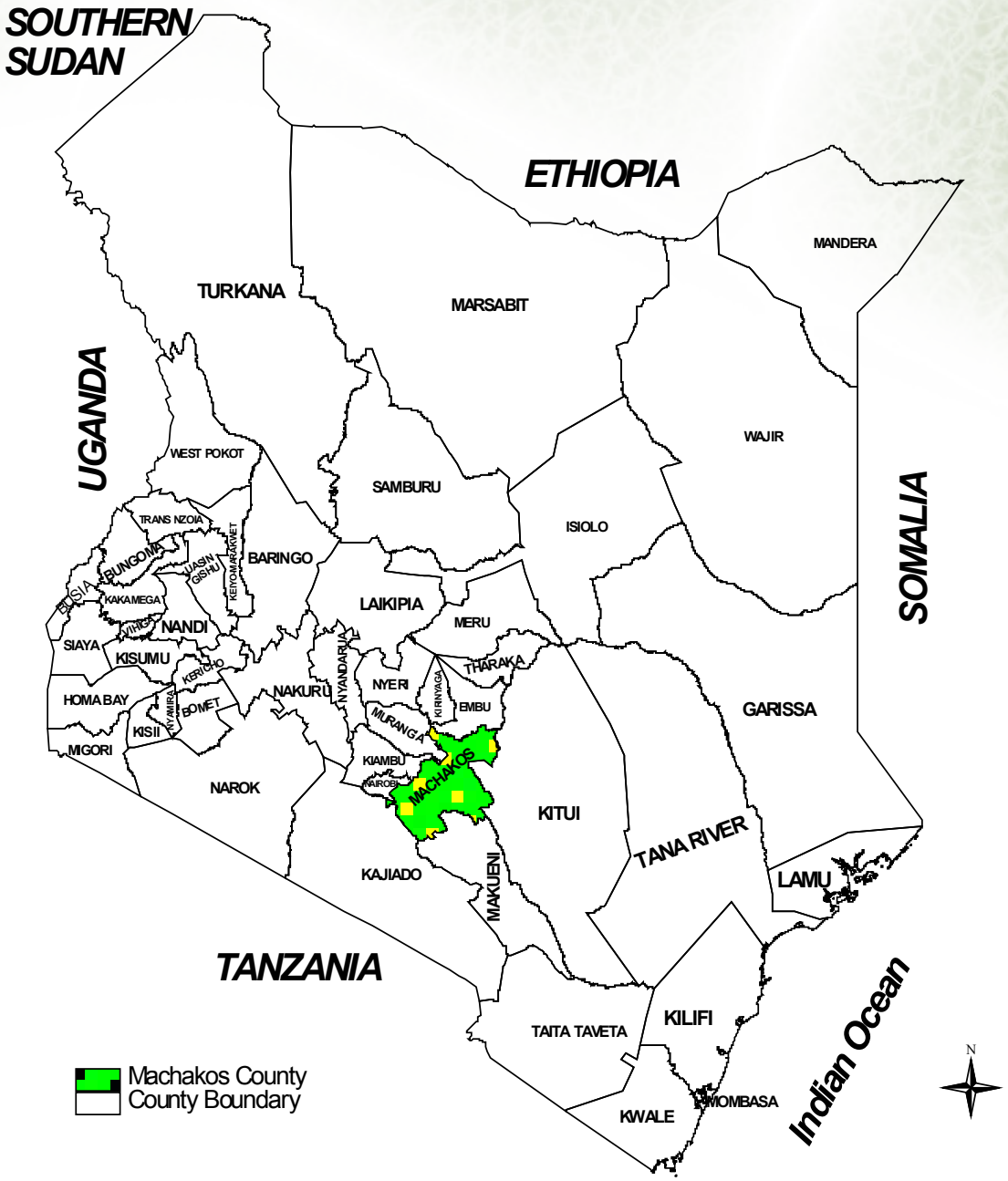

Figure 1. Map showing the administrative counties in Kenya (Source: 'ILRI (2007). Kenya divisional boundaries as at the year 2000. International Livestock Research Institute (ILRI), Nairobi, Kenya. http://www.ilri.org)

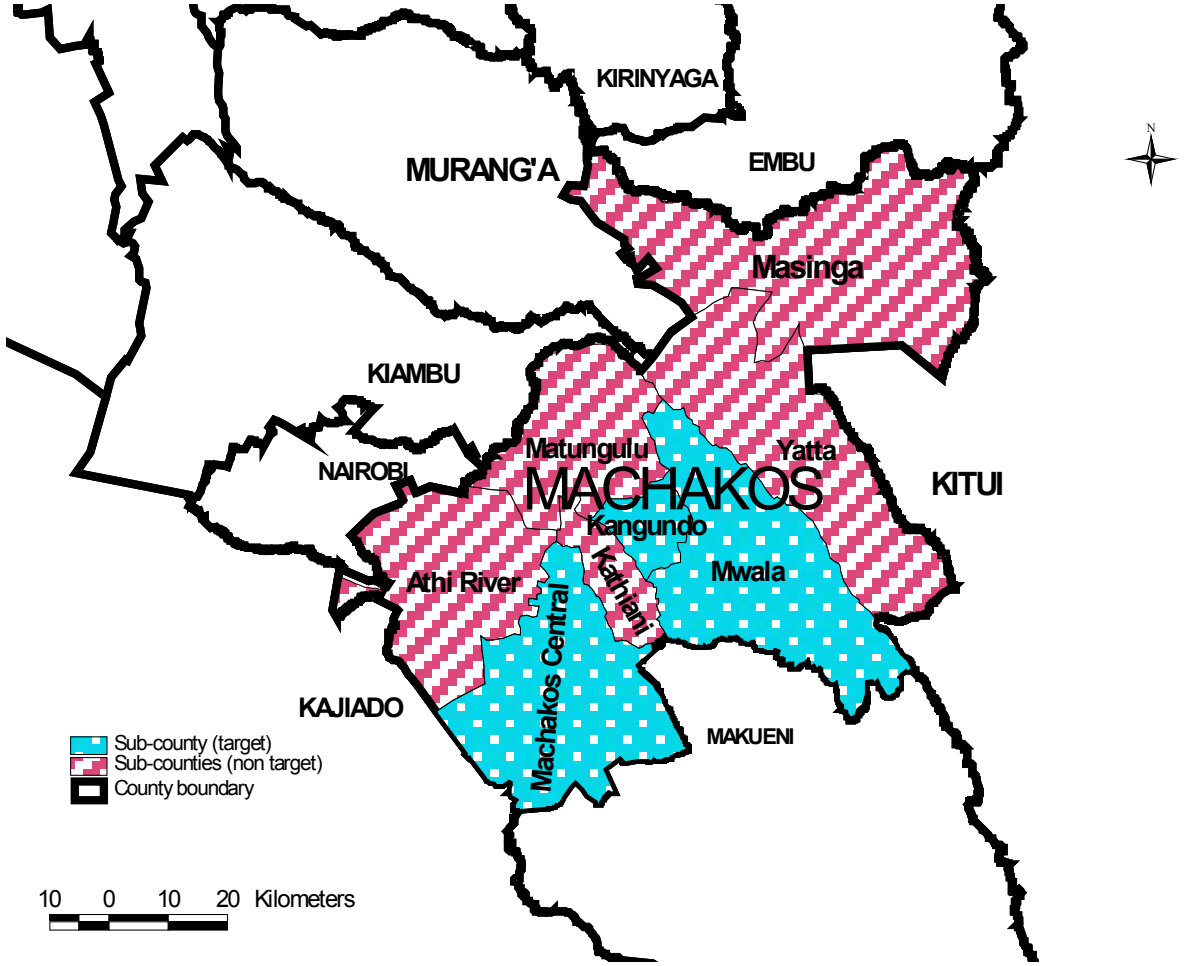

Figure 2. Map showing the administrative sub-counties in Machakos County (Source: GoK, 2012. Preliminary report on the first review relating to the delimitation of boundaries and wards, 9th January 2012. The independent Electoral and Boundaries commission (IEBC), Kenya)

The County constitutes eight sub-counties namely Machakos central, Athi River, Kangundo, Matungulu, Kathiani, Mwala, Masinga and Yatta (Figure 2) with a combined population of 1,098,584 persons, a population density of 177 people per Km^2 and a poverty level of 59.6% (Table 1).

Table 1. General information and statistics on Machakos County	
Population	1,098,584
Surface area (km^2)	6,208
Density (people per km^2)	177
Poverty rate, based on KIHBS (%)	59.6
Share of urban population (%)	52.0
Urban population in largest towns	
- Kangundo-Tala	218,557
- Machakos	150,041
- Mavoko	137,211
- Kathiani	3,365
- Masii	2,501

Source: Commission on Revenue Allocation (2011)

Generally, the County is semi-arid, hilly at an altitude range of between 1,000 to 1,600 metres above sea level. Temperatures range between a minimum of 9.1^{0}C to a maximum of 26.7 ^{0}C while annual rainfall ranges between 500 and 900 mm. The County receives bimodal rainfall with long rains occurs from March to May while the short rains are experienced from October and November. The agro-ecological zones range from moist and cool climate on the hill tops belonging to agro-ecological zone LH2 (referred to as wheat/maize-pyrethrum zone) to LM5 which is most dry and referred to as livestock-millet zone. The County covers an area of 6,281.4 km^2 most of which is semi-arid with only 26% of the total area being suitable for agriculture. Kagundo and Kathiani sub-counties have fertile soils and this is where the main farming activities are concentrated. Machakos soils are generally sandy loam with low water holding capacity.

The typical characteristic of agriculture in this County is small-scale farming, with great variation due to land use potential which varies considerably depending on the agro-ecological zones. The main economic activities include farming, eco-tourism, businesses and manufacturing. Dairy, poultry, goats and bee keeping are among the main livestock activities while crops such as mangoes, paw paws, water melons, maize, sorghum, millet, cow peas, beans, pigeon peas and lentils are produced.

With a population growth rate of 3.09%, diminishing land sizes in the fertile land, large tracks of underutilized land in the marginal areas, dairy farming becomes an attractive agricultural venture. Dairy farming may be done in the most arid parts of the County if strategic feeding is applied. Moreover feeds can be conserved during the period of plenty, bought cheaply and transported, and stored for feeding during the period of scarcity.
Marketing of milk is mainly through informal markets and dairy co-operative societies such as Wamunyu and Masii Dairy Farmers' Co-operatives are among the most progressive. With the close proximity to populous Nairobi city and co-operative marketing taking lead in milk marketing, dairy can be a profitable enterprise in the County.

1.2 Diagnostic survey
A diagnostic survey was conducted from 14th-18th August 2011 in three sub-counties (Kangundo; agro-ecological zone UM2, Machakos central; agro-ecological zone UM3-UM4 and Mwala; agro-ecological zone UM3-UM4) in Machakos 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 using dairy production systems as independent variables using Microsoft Office Excel (2007). For each parameter, 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. The 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.

About 60% of the household heads interviewed during the survey were practicing zero-grazing dairy production systems (Table 2).

Table 2. Proportions (%) of household heads interviewed by production system		
Production system	**n**	**Percentage**
Zero-grazing	183	59.61
Semi-zero grazing	116	37.79
Free grazing	7	2.28
Production system not indicated	1	0.33
Total	**307**	**100.00**

On average, 82.7% of the households were headed by males (Table 3). Furthermore, about 46% of the household heads were 50 years old and above (Table 3).
About 56% of household heads had secondary education as the highest level of formal education (Table 4).

Table 3. Proportion (%) of gender and age group of household head by production system						
Production system	**n**	**Male household heads (%)**	**Age group of household heads (years)**			
			<35	**35-50**	**>50**	**Age not Indicated**
Zero-grazing	183	81.97	12.57	44.26	43.17	0.00
Semi-zero grazing	116	85.34	3.45	46.55	49.14	0.86
Free grazing	7	71.43	0.00	42.86	57.14	0.00
Mean (n=306)		**82.74**	**8.79**	**45.28**	**45.60**	**0.33**

Table 4. Proportion (%) of household heads by highest level of formal education and production system							
Production system	**n**	**Highest level of formal education**					
		None	**Primary**	**Secondary**	**Tertiary**	**University**	**Not indicated**
Zero-grazing	183	2.19	19.13	57.38	13.66	7.10	0.55
Semi Zero-grazing	116	0.86	21.55	56.90	13.79	6.03	0.86
Free grazing	7	14.29	57.14	14.29	14.29	0.00	0.00
Mean (n=306)		**1.95**	**21.17**	**56.03**	**13.68**	**6.51**	**0.65**

1.4 Dairy breeds and herd size

The Friesian dairy breed was the most popular as it was kept by about 63% of the households (Table 5). A slightly higher proportion of households practicing zero-grazing dairy production systems kept Friesians as compared to those practicing semi-zero grazing dairy production systems (Table 5). Not surprisingly, crosses were more predominant under free grazing dairy production systems (Table 5).

Table 5. Proportion (%) of households keeping various dairy cattle breeds by production system									
Production system	**n**	**Friesian**	**Ayrshire**	**Crosses**	**Zebu**	**Jersey**	**Guernsey**	**Sahiwal**	**Boran**
Zero-grazing	183	65.57	31.15	15.85	3.83	1.64	2.19	0.55	0.00
Semi-zero grazing	116	61.21	18.10	21.55	7.76	3.45	1.72	2.59	2.59
Free grazing	7	28.57	14.29	28.57	14.29	0.00	0.00	0.00	14.29
Mean (n=306)		**63.07**	**25.82**	**18.30**	**5.56**	**2.29**	**1.96**	**1.31**	**1.31**

The mean herd size in the County was about four animals, with lactating cows being a large proportion (38.4%) of the herd (Table 6).

Table 6. Dairy herd size and structure by production system									
Production system	**n**	**Mean herd size**	**SE**	**Herd structure in relation to herd size (%)**					
				Lactating Cows	**Dry Cows**	**Heifers**	**Weaned calves**	**Pre-weaned calves**	**Mature Bulls**
Zero-grazing	183	3.5	0.28	43.29	19.43	12.32	8.37	13.74	2.84
Semi-zero grazing	116	5.2	0.54	33.28	13.92	11.38	15.62	11.21	14.60
Free grazing	7	4.2	1.33	36.00	16.00	4.00	16.00	20.00	8.00
Mean (n=306)		**4.2**	**0.27**	**38.41**	**16.76**	**11.71**	**11.95**	**12.67**	**8.50**

1.5 Milk production

The average milk yield in the County was 9.0 kg/cow/day with households practicing zero-grazing dairy production systems having a higher production from their dairy cows (Table 7). Generally, majority (67.82%) of the farmers in the County produced not more than 10 kg/cow/day (Table 8). The average price of raw milk was KES 36.99 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	150	17.47	1.605	262	10.00	0.354
Semi-zero grazing	99	13.42	1.386	175	7.59	0.353
Free grazing	6	9.50	3.212	8	7.13	1.716
Mean	**255**	**15.71**	**1.096**	**445**	**9.00**	**0.258**

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	150	16.67	44.00	24.70	10.67	4
Semi-zero grazing	99	34.34	44.40	14.10	6.06	1.01
Free grazing	6	33.33	33.30	16.70	16.67	-
Mean (n= 255)		**23.92**	**43.9**	**20.40**	**9.02**	**2.75**

Table 9. Prices of raw milk (KES/kg) by production system			
Production system	**n**	**Mean**	**S.E**
Zero-grazing	160	37.91	0.455
Semi-zero grazing	89	35.42	0.690
Free grazing	6	35.83	3.270
Mean (n=255)		**36.99**	**0.387**

1.6 Forage production

A large proportion (94.8%) of the household heads interviewed were growing maize which would provide both grain for human consumption and mainly maize stover for dairy feeding. About 64% of

the households grew Napier grass amongst other pastures and fodders (Table 10). The proportion of households growing fodder trees and other high protein forages was low (Table 11). The average farm size was 8.6 acres while the area under pastures and fodders was 1.9 acres (Table 12). The average number of fodder trees was 12.4 (Table 12). The average area under Napier grass was 0.8 acres (Table 13). Acacia formed the highest number (7.8) 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					
		Maize	Napier grass	Natural pastures	Rhodes grass	Unspecified Improved grass	[1]Other pastures and fodders
Zero-grazing	183	91.80	76.50	9.29	6.56	0.55	4.37
Semi Zero-grazing	116	99.14	44.83	43.10	25.00	14.66	25.00
Free grazing	7	100.00	42.86	14.29	0.00	0.00	0.00
Mean (n=306)		**94.77**	**63.73**	**22.22**	**13.40**	**5.88**	**12.09**

[1]Other pastures and fodders included Bracharia grass, Star grass, Panicum, Eragrostis, Unspecified legumes, Lucerne, Fodder maize, Sunflower, Sudan grass, Nanuga grass, Kow kandy and Desmodium

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					
		Leucaena	Calliandra	Sesbania	Acacia	Sweet potatoes	[1]Others
Zero-grazing	183	8.20	15.30	7.10	0.55	6.56	5.47
Semi Zero-grazing	116	25.00	1.72	11.21	12.93	1.72	6.03
Free grazing	7	0.00	0.00	0.00	0.00	0.00	0.00
Mean (n=306)		**14.38**	**9.80**	**8.50**	**5.23**	**4.58**	**5.62**

[1]Others included *Cassia siamea*, Sunflower, Mulberry, Lucerne, Desmodium and unspecified legumes

Table 12. Farm size and pasture and fodder production by production system

Production system	Statistic	Farm size (acres)	Area under pastures and fodders (acres)	No. of fodder trees
Zero-grazing	n	177	115	26
	Mean	5.80	1.06	6.50
	SE	0.660	0.127	1.034
Semi-zero grazing	n	112	85	28
	Mean	12.57	3.08	17.93
	SE	3.653	0.540	3.515
Free grazing	n	7	3	-
	Mean	17.14	2.00	-
	SE	7.957	1.500	-
Mean	**n**	**296**	**203**	**54**
	Mean	**8.63**	**1.92**	**12.43**
	SE	**1.459**	**0.247**	**2.030**

Table 13. Acreage under various forages by production system						
Production system	**Statistic**	**[1]Maize**	**Natural pastures**	**Rhodes grass**	**Napier grass**	**Sweet potato vines**
Zero-grazing	n	154	20	9	103	7
	Mean	1.76	1.54	1.53	0.69	0.43
	SE	0.155	0.453	0.620	0.074	0.080
Semi-zero grazing	n	106	61	24	45	-
	Mean	2.85	2.08	1.07	0.91	-
	SE	0.212	0.201	0.214	0.121	
Free grazing	n	7	1	-	2	-
	Mean	4.71	5.00	-	0.50	-
	SE	1.565	0.000		0.000	
Mean	**n**	**267**	**82**	**33**	**150**	**7**
	Mean	**2.27**	**1.99**	**1.20**	**0.76**	**0.43**
	SE	**0.135**	**0.190**	**0.230**	**0.060**	**0.080**
[1]Maize crop as a source of maize stover						

Table 14. Number of fodder trees per household by production system						
Production system	**Statistic**	**Acacia**	**Sesbania**	**Leucaena**	**Calliandra**	**Mulberry**
Zero-grazing	n	1	11	10	10	4
	Mean	10.00	4.09	5.20	5.40	1.25
	SE	0.000	0.732	1.533	1.231	0.250
Semi-zero grazing	n	14	11	22	1	-
	Mean	7.64	11.18	8.23	15.00	-
	SE	1.051	1.016	2.486	0.000	
Free grazing	n	-	-	-	-	-
	Mean	-	-	-	-	-
	SE	-	-	-	-	-
Mean	**n**	**15**	**22**	**32**	**11**	**4**
	Mean	**7.80**	**7.64**	**7.28**	**6.27**	**1.25**
	SE	**0.991**	**0.986**	**1.776**	**1.415**	**0.250**

1.7 Utilization of feeds by lactating cows

Dairy cattle were fed with various basal forages during the wet and dry seasons. The basal forages used during the wet season were Napier grass, maize stover, natural pastures and grass hay (Table 15). The basal forages used during the dry season were Napier grass, maize stover, natural pastures, grass hay and banana leaves & stems (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**	**Natural pastures**	**Grasshay**	**[1]Other basal forages**
Zero-grazing	183	73.22	43.72	27.32	13.11	6.01
Semi-zero grazing	116	43.10	23.28	31.03	10.34	9.48
Free grazing	7	14.29	0.00	57.14	57.14	0.00
Mean (n=306)		**60.26**	**34.85**	**29.32**	**13.03**	**7.17**
[1]Other basal forages include Vegetables, Banana leaves and stems, Rhodes grass, Crop residues, Pigeon pea pods, Bean straws and husks and Garden pea leaves						

Table 16. Proportion (%) of households feeding lactating cows with various basal forages during dry season by production system							
Production system	**n**	**Napier grass**	**Maize stover**	**Natural pastures**	**Grass hay**	**Banana leaves & stems**	**[1]Other basal forages**
Zero-grazing	183	48.09	47.54	34.97	24.04	13.11	1.64
Semi-zero grazing	116	28.45	18.10	29.31	10.34	2.59	18.10
Free grazing	7	0.00	0.00	0.00	42.86	0.00	0.00
Mean (n=306)		**39.41**	**35.18**	**31.92**	**19.22**	**8.79**	**0.00**
[1]Other basal forages include Bean straws and husks, Vegetables, Rhodes grass, Avocado leaves, Crop residues, potato peels ,Pigeon pea leaves and pods and Garden pea leaves							

Forage supplements (e.g. fodder trees, legumes, sweet potato vines) were rarely used by dairy farmers during wet and dry seasons (Tables 17 and 18). The forage supplements used during the wet season included sweet potato vines, calliandra, sesbania, leucaena, desmodium and lucerne (Table 17).

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

Table 17. Proportion (%) of households feeding lactating cows with various supplementary forages during wet season by production system									
Production system	**n**	**[1]SPV**	**Calliandra**	**Unspecified Legumes**	**Sesbania**	**Leucaena**	**Desmodium**	**Lucerne**	**[2]Supplementing (%)**
Zero-grazing	183	21.86	4.37	0.00	3.28	2.19	0.55	0.55	28.42
Semi-zero grazing	116	6.03	0.86	7.76	0.00	0.86	0.86	0.00	14.66
Free grazing	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean (n=306)		**15.31**	**2.93**	**2.93**	**1.95**	**1.63**	**0.65**	**0.33**	**22.48**
[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 system	**n**	**[1]SPV**	**Leucaena**	**Acacia pods**	**Unspecified Legumes**	**Calliandra**	**Sesbania**	**Desmodium**	**Lucerne**	**[2]Supplementing (%)**
Zero-grazing	183	10.38	1.09	0.00	0.00	1.09	1.64	0.55	0.55	13.66
Semi-zero grazing	116	4.31	4.31	3.45	3.45	0.86	0.00	0.00	0.00	12.93
Free grazing	7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean (n=306)		**7.82**	**2.28**	**1.30**	**1.30**	**0.98**	**0.98**	**0.33**	**0.33**	**13.03**

[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 75% of the households during the wet season (Table 19). The other concentrates or feed ingredients used during the wet season were maize germ, molasses and wheat bran. Similarly, dairy meal was used by majority (69.38) of the households during the dry season (Table 20). The other concentrates or feed ingredients used during the dry season were maize germ, molasses, wheat bran, cotton seed cake and fish meal.

Table 19. Proportion (%) of households supplementing lactating cows with various commercial concentrates during wet season by production system						
Production system	**n**	**Dairy meal**	**Maize germ**	**Molasses**	**Wheat bran**	**[1]Supplementing (%)**
Zero-grazing	183	83.61	12.02	1.64	0.55	84.15
Semi-zero grazing	116	64.66	5.17	3.45	0.86	61.21
Free grazing	7	42.86	14.29	0.00	0.00	57.14
Mean (n=306)		**75.24**	**9.45**	**2.28**	**0.65**	**74.59**

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

Table20. Proportion (%) of households supplementing lactating cows with various commercial concentrates during dry season by production system								
Production system	**n**	**Dairy meal**	**Maize germ**	**Molasses**	**Wheat bran**	**Cotton seed cake**	**Fish meal**	**[1]Supplementing (%)**
Zero-grazing	183	80.33	18.58	5.46	0.55	0.55	0.55	81.42
Semi-zero grazing	116	54.31	6.03	6.90	0.86	0.00	0.00	55.17
Free grazing	7	42.86	0.00	0.00	0.00	0.00	0.00	42.86
Mean (n=306)		**69.38**	**13.36**	**5.86**	**0.65**	**0.33**	**0.33**	**70.36**
[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 show that farmers supplemented dairy cattle with minerals during the wet and dry seasons. Unga high phosphorous was used by about 41% of the farmers during the wet season (Table 21). Similarly, Unga high phosphorous was used by about 37% of the farmers during the dry season (Table 22). Other commercial mineral salts used during the wet and dry seasons included Maclic super, Vitaphos, Baymix maziwa and Afya bora.

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

Production system	n	[1]UHP	[2]UMB	[3]MS	[4]UMS	[5]BM	Holland	[6]CS	[7]VP	[8]Others	[9]Supplementing (%)
Zero-grazing	183	44.26	12.02	10.93	5.46	6.56	2.73	2.19	1.64	0.55	85.79
Semi-zero grazing	116	35.34	8.62	2.59	6.03	0.00	0.86	1.72	1.72	3.44	60.34
Free grazing	7	57.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.14
Mean (n=306)		**41.18**	**10.46**	**7.52**	**5.56**	**3.92**	**1.96**	**1.96**	**1.63**	**1.64**	**75.24**

[1]Unga high phosphorus, [2]Unidentified mineral block, [3]Maclic super, [4]Unidentified mineral salt, [5]Baymix maziwa, [6]Common salts, [7]Vitaphos, [8]Others included Morendat salt, calcium salt and Bio-plus salt, [9]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	[1]UHP	[2]UMB	[3]MS	[4]BM	[5]VM	[6]CS	[7]UMS	Holland	[8]Others	[9]Supplementing (%)
Zero-grazing	183	40.98	9.84	10.93	6.01	2.19	2.19	3.83	2.73	2.20	79.23
Semi-zero grazing	116	28.45	8.62	2.59	0.00	4.31	4.31	0.86	0.86	4.31	54.31
Free grazing	5	60.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.86
Mean (n=304)		**36.51**	**9.21**	**7.57**	**3.62**	**2.96**	**2.96**	**2.63**	**1.97**	**2.97**	**68.73**

[1]Unga high phosphorus, [2]Unidentified mineral block, [3]Maclic super, [4]Baymix maziwa, [5]Vital maziwa, [6]Common salt, [7]Unidentified mineral salt, [8]Others included Morendat salt, calcium salt, DCP, Milk plus salt and Mega plus salt, [9]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 seven per cent (Table 23).

Table 23. Proportion (%) of household heads trained on ration formulation by production system

Production system	n	Trained (%)
Zero-grazing	183	7.10
Semi-zero grazing	116	7.76
Free grazing	7	0.00
Mean (n=306)		**7.19**

Only farmers practicing zero-grazing and semi-zero grazing dairy production systems formulated home-made concentrates (Table 24). Overall, 1.6% of farmers formulated home-made concentrates during the wet season while 5.6% 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. Furthermore, it was observed that farmers did not have the required skills and 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	183	0.55	0.55
Semi-zero grazing	116	3.45	13.79
Free grazing	7	0.00	0.00
Mean (n=306)		**1.63**	**5.56**

1.9 Objective

The main objective was to formulate least cost dairy ration options for lactating dairy cows using readily available feed resources and document the ration options for ease of use by dairy farmers and other stakeholders in Machakos County.

2.0 FORMULATION OF DAIRY RATIONS

2.1 PC dairy 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 daily 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 9.0 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 about 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). 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 Machakos County livestock production officers as detailed in Table 25.

Table 25. Quality and cost of dairy feed resources in Machakos County								
Feed resources	**DM**	**CP**	**CF**	**Ash**	**Ca**	**P**	**[1]MVI**	**[2]Cost (KES/kg as fed)**
Napier grass (young maturity)	15.50	11.00	33.70	17.70	0.38	0.34	1.20	4.50
Napier grass (medium maturity)	17.50	8.00	36.10	12.40	0.60	0.41	1.30	3.00
[3]Natural pastures (medium maturity)	30.20	9.00	33.30	7.40	0.40	0.20	1.30	3.00
[3]Natural pastures (old maturity)	35.00	7.50	39.20	8.50	0.40	0.20	1.40	7.00
Rhodes grass hay	85.00	8.00	40.00	10.00	0.50	0.31	1.30	16.60
Maize stover	80.00	4.30	37.90	6.50	0.35	0.19	1.40	2.50
Sweet potato vines	10.30	17.50	15.00	9.30	1.16	0.42	1.00	4.50
Calliandra leaves	21.90	22.40	15.00	12.00	0.90	0.15	1.20	4.50
Leucaena leaves	24.10	21.60	18.10	10.50	0.54	0.29	1.20	4.50
Dairy meal (standard)	95.00	16.00	12.20	7.00	0.60	0.40	-	26.00
Dairy meal (high yielder)	95.00	18.00	12.20	7.00	0.70	0.50	-	34.00
Cotton seed cake	92.00	35.00	23.20	6.60	0.19	0.20	-	60.00
Maize bran	90.00	12.00	12.00	3.00	0.10	0.05	-	20.00
Maize germ	91.00	14.00	15.20	7.00	0.10	0.50	-	23.00
Wheat bran	87.60	16.90	11.30	6.40	0.14	0.65	-	20.00
Cane molasses	74.00	4.20	0.00	8.60	0.90	0.10	-	25.00
Mineral pre-mix	89.00	0.00	0.00	70.50	18.51	11.00	-	150.00
Di-calcium phosphate	97.00	0.00	0.00	86.80	22.00	19.3	-	300.00
Stock lime	100.00	0.00	0.00	95.80	34.00	0.02	-	7.00

DM=dry matter, CP=crude protein, CF = crude fibre, Ca=calcium, P=phosphorous
[1]Maximum voluntary intake (MVI) factor (range: 1.00 to 1.40: excellent quality = 1.00, fair quality = 1.40)
[2]Costs were estimated in a workshop involving the investigators and District Livestock Production Officers and other extension officers in Machakos County
[3]Natural pastures included star grass, hyparrhenia, couch grass

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, natural pastures or forage mixtures.
Furthermore, the rations have been coded. For example, MA10Z1 means Machakos ration no 1 for producing 10 kg milk per cow per day under zero-grazing dairy production system. Similarly, MA15Z6 means Machakos ration no 6 for producing 15 kg milk per cow per day under zero-grazing dairy production system.

It should be noted that the quantities of ingredients used in formulation of dairy rations and their resultant qualities will vary depending on milk yield, live-weight, parity, milk butter-fat, and live-weight changes of the dairy cows and the quality of feed on offer. For this reasons, farmers may get different milk yield responses if their cows and quality of feed resources differ from the values used to formulate dairy rations in this document.

Table 26. Dairy ration options for producing 10 kg milk/cow/day by a cow weighing 400 kg 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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SL			
Napier grass based rations															
MA10Z1	DM basis (kg)	7.36							4.87			1.38	13.60	334.48	54:46
	As fed basis (kg)	47.49							5.56			1.38	54.42		
MA10Z2	DM basis (kg)	6.62						0.74	3.98			1.66	13.00	308.47	57:43
	As fed basis (kg)	42.74						3.05	4.54			1.66	51.99		
MA10Z3	DM basis (kg)	6.62				0.74			5.05	0.16		1.85	14.42	356.25	51:49
	As fed basis (kg)	42.74				7.15			5.77	0.18		1.85	57.67		
Rhodes grass hay based rations															
MA10Z4	DM basis (kg)		7.36						2.63		0.75	0.06	10.80	253.11	68:32
	As fed basis (kg)		8.66						3.00		0.82	0.06	12.53		
MA10Z5	DM basis (kg)		6.62					0.74	3.75		0.09	0.08	11.28	235.12	65:35
	As fed basis (kg)		7.79					3.05	4.28		0.10	0.08	15.31		
MA10Z6	DM basis (kg)		6.62			0.74			2.69		0.43	0.05	10.53	251.24	70:30
	As fed basis (kg)		7.79			7.15			3.07		0.47	0.05	18.53		
MA10Z7	DM basis (kg)		4.45				2.25		2.94			0.14	9.68	203.08	69:31
	As fed basis (kg)		5.25				2.52		3.25			0.14	11.13		
Maize stover based rations															
MA10Z8	DM basis (kg)			7.36					4.55		1.55	0.10	13.56	228.53	54:46
	As fed basis (kg)			9.20					5.19		1.69	0.10	16.18		
MA10Z9	DM basis (kg)			6.62				0.74	3.52		1.20	0.08	12.16	193.61	61:39
	As fed basis (kg)			8.28				3.05	4.02		1.30	0.08	16.73		
MA10Z10	DM basis (kg)			6.62		0.74			3.76		1.28	0.07	12.47	222.59	59:41
	As fed basis (kg)			8.28		7.15			4.29		1.39	0.07	21.18		
MA10Z11	DM basis (kg)			3.45			3.25		2.69				9.39	143.36	71:29
	As fed basis (kg)			3.71			3.64		3.07				10.42		
Natural pastures based rations															
MA10Z12	DM basis (kg)				7.36				2.19		0.51	0.04	10.11	156.94	73:27
	As fed basis (kg)				24.37				2.50		0.56	0.04	27.47		
MA10Z13	DM basis (kg)				6.62			0.74	2.58		0.03	0.04	10.01	140.58	74:26
	As fed basis (kg)				21.93			3.05	2.94		0.03	0.04	28.00		
MA10Z14	DM basis (kg)				6.62	0.74			2.02		0.27	0.03	9.67	161.90	76:24
	As fed basis (kg)				21.93	7.15			2.30		0.30	0.03	31.70		
Forage mixtures based rations															
MA10Z15	DM basis (kg)	0.74	6.62						2.58		0.67	0.06	10.67	253.50	69:31
	As fed basis (kg)	4.75	7.79						2.94		0.73	0.06	16.27		
MA10Z16	DM basis (kg)	0.74	5.89					0.75	3.70		0.01	0.09	11.15	235.51	66:34
	As fed basis (kg)	4.75	6.93					3.05	4.23		0.01	0.09	19.05		

Table 26. Dairy ration options for producing 10 kg milk/cow/day by a cow weighing 400 kg 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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SL			
MA10Z17	DM basis (kg)	0.74	5.89			0.74			2.64		0.34	0.05	10.40	251.63	71:29
	As fed basis (kg)	4.75	6.93			7.15			3.02		0.37	0.05	22.26		
MA10Z18	DM basis (kg)	0.74		6.62					4.15		1.42	0.10	13.02	229.84	57:43
	As fed basis (kg)	4.75		8.28					4.74		1.54	0.10	19.40		
MA10Z19	DM basis (kg)	0.74		5.89				0.74	3.13		1.07	0.07	11.62	194.93	63:37
	As fed basis (kg)	4.75		7.36				3.05	3.57		1.16	0.07	19.96		
MA10Z20	DM basis (kg)	0.74		5.89		0.74			3.37		1.15	0.07	11.94	223.91	62:38
	As fed basis (kg)	4.75		7.36		7.15			3.84		1.24	0.07	24.41		
MA10Z21	DM basis (kg)	0.74			6.62				2.04		0.48	0.04	9.93	165.54	74:26
	As fed basis (kg)	4.75			21.93				2.33		0.52	0.04	29.58		
MA10Z22	DM basis (kg)	0.75			6.04			0.75	2.48			0.04	10.07	152.81	75:25
	As fed basis (kg)	4.87			19.98			3.13	2.82			0.04	30.85		
MA10Z23	DM basis (kg)	0.74			5.89	0.74			1.87		0.24	0.03	9.50	170.50	78:22
	As fed basis (kg)	4.75			19.50	7.15			2.13		0.26	0.03	33.81		

[1]Young Napier grass, [2]Rhodes grass hay, [3]maize stover, [4]Natural pastures, [5]Sweet potato vines, [6]Lucerne hay, [7]Leucaena dry leaves, [8]Wheat bran, [9]Maize germ, [10]Cotton seed cake, [11]Stock lime

Table 27. Dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400 kg 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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SBC	[12]SL			
Napier grass based rations																
MA15Z1	DM basis (kg)	6.26						1.10	7.45	1.18	0.41		0.23	9.26	430.32	44:56
	As fed basis (kg)	40.36						4.58	8.51	1.29	0.44		0.23	10.47		
Rhodes grass hay based rations																
MA15Z2	DM basis (kg)		7.36						6.16		2.10		0.15	15.78	422.64	47:53
	As fed basis (kg)		8.66						7.03		2.29		0.15	18.13		
MA15Z3	DM basis (kg)		6.62					0.74	4.96		1.69		0.12	14.13	367.60	52:48
	As fed basis (kg)		7.79					3.05	5.66		1.84		0.12	18.47		
MA15Z4	DM basis (kg)		6.62			0.74			5.31		1.81		0.12	14.60	401.70	50:50
	As fed basis (kg)		7.79			7.15			6.07		1.97		0.12	23.09		
MA15Z5	DM basis (kg)		3.27				3.43		3.70		1.00		0.24	11.63	293.18	58:42
	As fed basis (kg)		3.85				3.84		4.22		1.11		0.24	13.25		
Maize stover based rations																
MA15Z6	DM basis (kg)			7.36					2.51			2.31	0.10	12.27	260.40	60:40
	As fed basis (kg)			9.20					2.86			2.56	0.10	14.72		
MA15Z7	DM basis (kg)			6.62				0.74	3.46			1.87	0.11	12.80	280.29	58:42
	As fed basis (kg)			8.28				3.05	3.95			2.08	0.11	17.47		
MA15Z8	DM basis (kg)			6.62		0.74			2.61			2.00	0.08	12.05	290.55	61:39
	As fed basis (kg)			8.28		7.15			2.98			2.22	0.08	20.71		
MA15Z9	DM basis (kg)			2.62			4.08		3.58		1.00		0.11	11.39	247.30	59:41
	As fed basis (kg)			2.82			4.56		4.09		1.11		0.11	12.69		
Natural pasture based rations																
MA15Z10	DM basis (kg)				7.36				5.27		1.79		0.11	14.53	311.05	51:49
	As fed basis (kg)				24.37				6.01		1.95		0.11	32.44		
MA15Z11	DM basis (kg)				6.62			0.74	4.16		1.42		0.09	13.02	256.45	57:43
	As fed basis (kg)				21.93			3.05	4.75		1.54		0.09	31.36		
MA15Z12	DM basis (kg)				6.62	0.74			4.51		1.53		0.09	13.48	290.31	55:45
	As fed basis (kg)				21.93	7.15			5.15		1.66		0.09	35.97		
Forage mixtures based rations																
MA15Z13	DM basis (kg)	0.74	6.62						5.90		2.02		0.15	15.42	417.93	48:52
	As fed basis (kg)	4.75	7.79						6.74		2.19		0.15	21.62		
MA15Z14	DM basis (kg)	0.74	5.89					0.74	4.70		1.61		0.12	13.78	362.89	53:47
	As fed basis (kg)	4.75	6.93					3.05	5.37		1.75		0.12	21.95		
MA15Z15	DM basis (kg)	0.74	5.89			0.74			5.05		1.72		0.12	14.25	396.99	52:48
	As fed basis (kg)	4.75	6.93			7.15			5.77		1.87		0.12	26.58		
MA15Z16	DM basis (kg)	5.76		1.60					4.83		1.66		0.14	13.99	391.47	53:47
	As fed basis (kg)	37.17		2.00					5.51		1.80		0.14	46.62		

Table 27. Dairy ration options for producing 15 kg milk/cow/day by a cow weighing 400 kg 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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SBC	[12]SL			
MA15Z17	DM basis (kg)	4.87		1.75				0.74	4.01		1.38		0.12	12.86	342.67	57:43
	As fed basis (kg)	31.44		2.19				3.05	4.58		1.49		0.12	42.87		
MA15Z18	DM basis (kg)	4.47		2.15		0.74			4.68		1.60		0.12	13.76	380.81	53:47
	As fed basis (kg)	28.84		2.69		7.15			5.34		1.74		0.12	45.88		
MA15Z19	DM basis (kg)	0.74			6.62				5.09		1.74		0.11	14.30	317.49	51:49
	As fed basis (kg)	4.75			21.93				5.82		1.89		0.11	34.50		
MA15Z20	DM basis (kg)	0.74			5.89			0.74	3.98		1.36		0.09	12.79	273.66	58:42
	As fed basis (kg)	4.75			19.50			3.05	4.55		1.48		0.09	33.41		
MA15Z21	DM basis (kg)	0.74			5.89	0.74			4.34		1.47		0.09	13.26	307.71	56:44
	As fed basis (kg)	4.75			19.50	7.15			4.95		1.60		0.09	38.03		

[1]Young Napier grass, [2]Rhodes grass hay, [3]maize stover, [4]Natural pastures, [5]Sweet potato vines, [6]Lucerne hay, [7]Leucaena dry leaves, [8]Wheat bran, [9]Maize germ, [10]Cotton seed cake, [11]Soya bean cake, [12]Stock lime

Table 28. Dairy ration options for producing 20 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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SBC	[12]SL			
Rhodes grass hay based rations																
MA20Z1	DM basis (kg)		7.36						5.06	0.20		1.81	0.16	14.58	425.78	50:50
	As fed basis (kg)		8.66						5.77	0.22		2.01	0.16	16.81		
MA20Z2	DM basis (kg)		6.62					0.74	5.51	0.53		1.50	0.17	15.08	417.36	49:51
	As fed basis (kg)		7.79					3.05	6.29	0.59		1.67	0.17	19.57		
MA20Z3	DM basis (kg)		6.62			0.74			5.12	0.11		1.57	0.14	14.31	421.97	51:49
	As fed basis (kg)		7.79			7.15			5.85	0.12		1.75	0.14	22.80		
MA20Z4	DM basis (kg)		1.89				4.82		5.57		1.00		0.32	13.58	340.32	49:51
	As fed basis (kg)		2.22				5.39		6.35		1.11		0.32	15.38		
Maize stover based rations																
MA20Z5	DM basis (kg)			7.36					4.01			2.67	0.14	14.19	353.28	52:48
	As fed basis (kg)			9.20					4.58			2.97	0.14	16.89		
MA20Z6	DM basis (kg)			6.62				0.74	4.94			2.25	0.16	14.71	348.63	50:50
	As fed basis (kg)			8.28				3.05	5.64			2.50	0.16	19.64		
MA20Z7	DM basis (kg)			6.62		0.74			4.12			2.36	0.13	13.96	357.33	53:47
	As fed basis (kg)			8.28		7.15			4.70			2.62	0.13	22.87		
MA20Z8	DM basis (kg)			1.52			5.18		5.50		1.00		0.24	13.44	313.68	50:50
	As fed basis (kg)			1.64			5.80		6.28		1.11		0.24	15.06		
Natural pastures based rations																

Table 28. Dairy ration options for producing 20 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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SBC	[12]SL			
MA20Z9	DM basis (kg)				7.36				4.13			1.57	0.12	13.17	307.35	56:44
	As fed basis (kg)				24.37				4.71			1.74	0.12	30.94		
MA20Z10	DM basis (kg)				6.62			0.74	5.05			1.26	0.13	13.79	307.22	53:47
	As fed basis (kg)				21.93			3.05	5.76			1.39	0.13	32.27		
MA20Z11	DM basis (kg)				6.62	0.74			4.22			1.36	0.10	13.04	315.92	56:44
	As fed basis (kg)				21.93	7.15			4.82			1.51	0.10	35.51		
Forage mixtures based rations																
MA20Z12	DM basis (kg)	4.42	2.94						6.55		2.25		0.18	16.34	482.96	45:55
	As fed basis (kg)	28.49	3.46						7.48		2.44		0.18	42.06		
MA20Z13	DM basis (kg)	3.68	2.94					0.74	5.43		1.86		0.15	14.80	424.27	50:50
	As fed basis (kg)	23.74	3.46					3.05	6.20		2.02		0.15	38.62		
MA20Z14	DM basis (kg)	3.68	2.94			0.74			5.85		2.00		0.15	15.36	461.41	48:52
	As fed basis (kg)	23.74	3.46			7.15			6.68		2.17		0.15	43.35		
MA20Z15	DM basis (kg)	0.74		6.62					4.07			2.52	0.14	14.10	359.93	52:48
	As fed basis (kg)	4.75		8.28					4.65			2.80	0.14	20.62		
MA20Z16	DM basis (kg)	0.74		5.89				0.74	5.01			2.10	0.16	14.62	355.28	50:50
	As fed basis (kg)	4.75		7.36				3.05	5.72			2.33	0.16	23.37		
MA20Z17	DM basis (kg)	0.74		5.89		0.74			4.18			2.20	0.13	13.87	363.98	53:47
	As fed basis (kg)	4.75		7.36		7.15			4.77			2.45	0.13	26.60		
MA20Z18	DM basis (kg)	0.74			6.62				4.18			1.52	0.12	13.18	318.52	56:44
	As fed basis (kg)	4.75			21.93				4.77			1.69	0.12	33.26		
MA20Z19	DM basis (kg)	0.74			5.89			0.74	5.10			1.21	0.14	13.80	318.48	53:47
	As fed basis (kg)	4.75			19.50			3.05	5.82			1.34	0.14	34.60		
MA20Z20	DM basis (kg)	0.74			5.89	0.74			4.58			1.31	0.12	13.37	333.84	55:45
	As fed basis (kg)	4.75			19.50	7.15			5.23			1.46	0.12	38.20		

[1]Young Napier grass, [2]Rhodes grass hay, [3]maize stover, [4]Natural pastures, [5]Sweet potato vines, [6]Lucerne hay, [7]Leucaena dry leaves, [8]Wheat bran, [9]Maize germ, [10]Cotton seed cake, [11]Soya bean cake, [12]Stock lime

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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SBC	[12]SL			
Rhodes grass hay based rations																
MA25Z1	DM basis (kg)		7.36						5.85	1.30		1.88	0.20	16.59	457.37	44:56
	As fed basis (kg)		8.66						6.68	1.43		2.08	0.20	19.05		
MA25Z2	DM basis (kg)		6.62					0.74	3.02	0.15	2.34	3.70	0.16	16.71	656.56	44:56
	As fed basis (kg)		7.79					3.05	3.44	0.16	2.54	4.11	0.16	21.25		
MA25Z3	DM basis (kg)		6.62			0.74			5.92	1.22		1.64	0.19	16.32	456.18	45:55
	As fed basis (kg)		7.79			7.15			6.76	1.34		1.82	0.19	25.04		
MA25Z4	DM basis (kg)		1.52				5.18		7.46		2.34		0.50	15.65	385.82	43:57
	As fed basis (kg)		1.79				5.79		8.51		2.54		0.50	17.70		
Maize stover based rations																
MA25Z5	DM basis (kg)			7.36					5.95			2.64	0.19	16.14	395.00	46:54
	As fed basis (kg)			9.20					6.79			2.94	0.19	19.11		
MA25Z6	DM basis (kg)			6.56				0.80	6.97			2.18	0.20	16.71	389.93	44:56
	As fed basis (kg)			8.20				3.33	7.95			2.43	0.20	22.10		
MA25Z7	DM basis (kg)			6.62		0.736			6.05			2.33	0.18	15.91	399.05	46:54
	As fed basis (kg)			8.28		7.146			6.91			2.59	0.18	25.09		
MA25Z8	DM basis (kg)			1.22			5.47		7.40		1.00		0.44	15.54	364.34	43:57
	As fed basis (kg)			1.32			6.12		8.45		1.11		0.44	17.44		
Natural pastures based rations																
MA25Z9	DM basis (kg)				7.58				5.84			1.59	0.16	15.15	350.49	50:50
	As fed basis (kg)				25.08				6.66			1.76	0.16	33.66		
MA25Z10	DM basis (kg)				7.24			0.80	6.35			1.36	0.16	15.91	353.70	51:49
	As fed basis (kg)				23.98			3.34	7.25			1.51	0.16	36.23		
MA25Z11	DM basis (kg)				6.84	0.76			5.91			1.38	0.14	15.03	359.59	51:49
	As fed basis (kg)				22.65	7.38			6.74			1.53	0.14	38.45		
Forage mixtures based rations																
MA25Z12	DM basis (kg)	0.74	6.62						5.87	1.22		1.80	0.20	16.45	457.07	45:55
	As fed basis (kg)	4.75	7.79						6.70	1.35		2.00	0.20	22.79		

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]MS	[4]NP	[5]SPV	[6]LH	[7]LL	[8]WB	[9]MG	[10]CSC	[11]SBC	[12]SL			
MA25Z13	DM basis (kg)	0.74	5.89					0.74	4.54	0.14	2.34	2.17	0.16	16.71	579.53	44:56
	As fed basis (kg)	4.75	6.93					3.05	5.18	0.16	2.54	2.41	0.16	25.18		
MA25Z14	DM basis (kg)	0.74	5.89			0.74			5.93	1.14		1.57	0.19	16.19	455.88	45:55
	As fed basis (kg)	4.75	6.93			7.15			6.77	1.26		1.74	0.19	28.78		
MA25Z15	DM basis (kg)	0.74		6.62					6.01			2.49	0.19	16.05	401.65	46:54
	As fed basis (kg)	4.75		8.28					6.86			2.76	0.19	22.84		
MA25Z16	DM basis (kg)	0.74		5.69				0.93	7.19			1.95	0.21	16.71	395.78	44:56
	As fed basis (kg)	4.75		7.12				3.86	8.20			2.17	0.21	26.31		
MA25Z17	DM basis (kg)	0.74		5.89		0.74			6.12			2.17	0.18	15.82	405.70	47:53
	As fed basis (kg)	4.75		7.36		7.15			6.98			2.41	0.18	28.8		
MA25Z18	DM basis (kg)	0.76			6.85				5.85			1.55	0.16	15.17	362.35	50:50
	As fed basis (kg)	4.91			22.68				6.68			1.72	0.16	36.14		
MA25Z19	DM basis (kg)	0.81			6.47			0.81	6.37			1.32	0.17	15.93	366.31	51:49
	As fed basis (kg)	5.21			21.41			3.36	7.27			1.46	0.17	38.88		
MA25Z20	DM basis (kg)	0.76			6.11	0.76			5.93			1.34	0.15	15.05	371.53	51:49
	As fed basis (kg)	4.93			20.22	7.41			6.77			1.49	0.15	40.96		

[1]Young Napier grass, [2]Rhodes grass hay, [3]maize stover, [4]Natural pastures, [5]Sweet potato vines, [6]Lucerne hay, [7]Leucaena dry leaves, [8]Wheat bran, [9]Maize germ, [10]Cotton seed cake, [11]Soya bean cake, [12]Stock lime

2.4 Expected nutrient composition and intake of formulated dairy ration options

The expected nutrient composition and intake of dairy rations formulated is as indicated in Tables 30a- 33b.

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 basal rations														
MA10Z1	25.00	1.42	34.24	12.00	15.15	26.73	22.28	22.40	29.32	1.65	21.55	0.00	3.69	0.42
MA10Z2	25.00	1.28	32.26	12.00	14.27	25.18	21.66	22.60	30.44	1.47	23.81	0.00	4.61	0.39
MA10Z3	25.00	1.40	33.73	12.00	13.49	25.55	20.34	21.54	28.00	1.77	23.16	0.00	4.64	0.41
Rhodes grass hay based basal rations														
MA10Z4	86.15	1.32	38.78	12.00	1.54	1.54	31.63	26.64	38.83	2.13	9.36	0.00	0.58	0.38
MA10Z5	73.70	1.26	29.74	12.00	0.18	0.18	28.61	26.64	35.24	1.71	9.44	0.00	0.63	0.42
MA10Z6	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 basal rations														
MA10Z7	56.83	1.35	39.45	12.00	1.76	4.82	30.05	26.70	38.65	2.08	9.29	0.00	0.60	0.40
MA10Z8	83.81	1.45	36.70	12.00	2.53	2.53	27.02	32.51	42.78	2.51	7.15	0.05	0.52	0.34
MA10Z9	72.65	1.35	35.71	12.00	2.19	2.19	27.31	33.66	45.50	2.24	7.28	0.05	0.49	0.33
MA10Z10	58.88	1.46	39.74	12.00	3.00	5.57	26.80	32.80	44.52	2.50	7.16	0.05	0.51	0.34
MA10Z11	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
Natural pasture based basal rations														
MA10Z12	36.79	1.53	33.15	12.00	1.13	1.13	27.88	32.07	42.21	1.07	7.49	0.00	0.47	0.30
MA10Z13	35.74	1.42	27.08	12.00	0.07	0.07	26.35	32.13	40.82	0.75	7.74	0.00	0.50	0.32
MA10Z14	30.52	1.55	35.57	12.00	1.56	4.88	26.95	32.01	42.91	1.10	7.55	0.00	0.49	0.31
Forage mixtures based basal rations														
MA10Z15	65.56	1.34	39.64	12.00	3.32	4.79	31.35	26.63	39.09	2.07	9,94	0.00	0.58	0.39
MA10Z16	58.55	1.28	30.45	12.00	1.86	3.27	28.30	26.62	35.44	1.65	10.00	0.00	0.63	0.42
MA10Z17	46.71	1.37	40.34	12.00	3.59	8.19	29.74	26.68	38.92	2.01	9.89	0.00	0.60	0.40
MA10Z18	67.12	1.45	38.08	12.00	3.99	5.20	27.31	32.21	43.19	2.45	7.78	0.05	0.52	0.35
MA10Z19	58.23	1.34	37.21	12.00	3.80	5.16	27.65	33.38	46.08	2.16	7.98	0.05	0.49	0.33
MA10Z20	48.91	1.46	41.38	12.00	4.61	8.62	27.11	32.48	45.05	2.43	7.84	0.05	0.52	0.34
MA10Z21	33.56	1.53	35.21	12.00	3.15	4.74	28.17	31.70	42.75	1.10	8.28	0.00	0.47	0.30
MA10Z22	32.62	1.42	29.09	12.00	2.10	3.70	26.63	31.77	41.37	0.78	8.54	0.00	0.49	0.33
MA10Z23	28.08	1.54	37.78	12.00	3.68	8.73	27.24	31.61	43.49	1.14	8.38	0.00	0.50	0.32

[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 10 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														
MA10Z1	13.60	19.34	4.66	1.63	2.06	3.64	3.03	3.05	3.99	0.23	2.93	0.00	0.50	0.06
MA10Z2	13.00	16.68	4.19	1.56	1.86	3.27	2.82	2.94	3.96	0.19	3.10	0.00	0.60	0.05
MA10Z3	14.42	20.16	4.86	1.73	1.95	3.68	2.93	3.11	4.04	0.26	3.34	0.00	0.67	0.06
Rhodes grass hay based rations														
MA10Z4	10.80	14.24	4.19	1.30	0.17	0.17	3.42	2.88	4.19	0.23	1.01	0.00	0.06	0.04
MA10Z5	11.28	14.24	3.36	1.35	0.02	0.02	3.23	3.01	3.98	0.19	1.07	0.00	0.07	0.05
MA10Z6	10.53	14.24	4.15	1.26	0.19	0.51	3.16	2.81	4.07	0.26	0.98	0.00	0.06	0.04
MA10Z7	9.68	12.61	3.37	1.16	0.10	0.26	2.54	2.97	5.53	0.16	1.01	0.00	0.07	0.05
Maize stover based rations														
MA10Z8	13.56	19.71	4.98	1.63	0.34	0.34	3.66	4.41	5.80	0.34	0.97	0.01	0.07	0.05
MA10Z9	12.16	16.35	4.34	1.46	0.27	0.27	3.32	4.09	5.53	0.27	0.89	0.01	0.06	0.04
MA10Z10	12.47	18.22	4.96	1.50	0.37	0.70	3.34	4.09	5.55	0.31	0.89	0.01	0.06	0.04
MA10Z11	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
Natural pastures based rations														
MA10Z12	10.11	15.50	3.35	1.21	0.11	0.11	2.82	3.24	4.27	0.11	0.76	0.00	0.05	0.00
MA10Z13	10.01	14.24	2.71	1.20	0.01	0.01	2.64	3.22	4.08	0.08	0.77	0.00	0.05	0.03
MA10Z14	9.67	14.96	3.44	1.16	0.15	0.47	2.61	3.10	4.15	0.11	0.73	0.00	0.05	0.03
Forage mixtures based rations														
MA10Z15	10.67	14.24	4.23	1.28	0.35	0.51	3.34	2.84	4.17	0.22	1.06	0.00	0.06	0.04
MA10Z16	11.15	14.24	3.40	1.34	0.21	0.37	3.16	2.97	3.95	0.18	1.12	0.00	0.07	0.05
MA10Z17	10.40	14.24	4.19	1.25	0.37	0.85	3.09	2.77	4.05	0.21	1.03	0.00	0.06	0.04
MA10Z18	13.02	18.94	4.96	1.56	0.52	0.68	3.56	4.20	5.62	0.32	1.01	0.01	0.07	0.05
MA10Z19	11.62	15.58	4.33	1.40	0.44	0.60	3.21	3.90	5.36	0.25	0.93	0.01	0.06	0.04
MA10Z20	11.94	17.45	4.94	1.43	0.55	1.03	3.24	3.88	5.38	0.29	0.94	0.01	0.06	0.04
MA10Z21	9.93	15.16	3.49	1.19	0.31	0.47	2.80	3.15	4.24	0.11	0.82	0.00	0.05	0.03
MA10Z22	10.07	14.24	2.93	1.21	0.21	0.37	2.68	3.20	4.16	0.08	0.86	0.00	0.05	0.03
MA10Z23	9.50	14.63	3.59	1.14	0.35	0.83	2.59	3.00	4.13	0.11	0.80	0.00	0.05	0.03

[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														
MA15Z1	30.00	1.52	31.06	15.00	11.08	19.14	20.60	23.49	28.00	2.808	12.20	0.00	0.72	0.48
MA15Z2	87.02	1.47	32.57	15.00	2.95	2.95	26.17	24.19	28.98	2.85	8.96	0.00	0.64	0.43
MA15Z3	76.52	1.37	31.72	15.00	2.65	2.65	26.44	25.15	31.31	2.62	9.07	0,00	0.62	0.41
Rhodes grass hay based rations														
MA15Z4	63.24	1.48	35.11	15.00	3.37	5.57	25.89	24.53	30.52	2.85	8.93	0.00	0.64	0.42
MA15Z5	83.35	1.44	45.76	15.00	1.18	6.71	25.04	31.49	43.72	2.17	7.22	0.06	0.56	0.38
MA15Z6	73.26	1.38	38.28	15.00	0.92	5.21	23.71	30.97	40.60	2.05	7.50	0.05	0.59	0.39
MA15Z7	87.81	1.38	35.21	15.00	3.23	5.29	23.71	27.93	51.11	2.32	10.47	0.00	0.91	0.61
Maize stover based rations														
MA15Z8	58.19	1.47	46.12	15.00	1.806	9.34	24.20	31.11	43.12	2.24	7.30	0.06	0.58	0.38
MA15Z9	44.79	1.61	29.24	15.00	2.73	2.733	23.83	28.06	31.82	2.13	7.63	0.00	0.54	0.36
MA15Z10	41.52	1.51	28.31	15.00	2.41	2.41	24.09	29.12	34.34	1.87	7.77	0.00	0.53	0.35
MA15Z11	89.76	1.41	36.81	15.00	3.56	6.064	25.39	30.03	51.17	2.29	8.65	0.02	0.85	0.57
Natural pastures based rations														
MA15Z12	37.48	1.62	32.09	15.00	3.19	5.572	23.59	28.32	33.41	2.14	7.63	0.00	0.54	0.36
MA15Z13	71.35	1.48	33.56	15.00	4.23	5.25	26.14	24.24	29.48	2.82	9.37	0.00	0.64	0.42
MA15Z14	62.77	1.38	32.81	15.00	4.08	5.22	26.414	25.237	31.932	2.58	9.53	0.00	0.62	0.41
Forage mixtures based rations														
MA15Z15	53.62	1.48	36.24	15.00	4.76	8.12	25.85	24.60	31.11	2.81	9.37	0.00	0.63	0.42
MA15Z16	30.00	1.57	40.44	15.00	14.16	22.97	24.86	25.83	33.98	2.64	12.00	0.01	0.62	0.41
MA15Z17	30.00	1.46	38.69	15.00	12.98	21.09	24.97	27.09	36.31	2.43	11.76	0.01	0.59	0.40
MA15Z18	30.00	1.57	41.07	15.00	12.33	21.61	24.22	26.55	34.93	2.73	11.05	0.02	0.61	0.41
MA15Z19	41.46	1.61	30.60	15.00	4.13	5.23	24.00	27.78	32.12	2.15	8.18	0.00	0.55	0.37

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														
MA15Z1	30.00	1.52	31.06	15.00	11.08	19.14	20.60	23.49	28.00	2.808	12.20	0.00	0.72	0.48
MA15Z20	38.28	1.50	29.80	15.00	3.96	5.19	24.30	28.84	34.74	1.90	8.37	0.00	0.53	0.35
MA15Z21	34.86	1.61	33.60	15.00	4.70	8.32	23.77	28.02	33.76	2.17	8.23	0.00	0.55	0.37
[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/c/d	[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														
MA15Z1	16.62	25.18	5.16	2.49	1.84	3.18	3.42	3.91	4.66	0.47	2.03	0.00	0.12	0.08
MA15Z2	15.78	23.14	5.14	2.37	0.47	0.47	4.13	3.82	4.57	0.45	1.41	0.00	0.10	0.07
MA15Z3	14.13	19.40	4.48	2.12	0.38	0.38	3.74	3.555	4.42	0.37	1.28	0.00	0.09	0.06
Rhodes grass hay based rations														
MA15Z4	14.60	21.54	5.13	2.19	0.49	0.81	3.78	3.58	4.46	0.42	1.30	0.00	0.09	0.06
MA15Z5	12.27	17.68	5.62	1.84	0.15	0.82	3.07	3.87	5.37	0.27	0.89	0.01	0.07	0.05
MA15Z6	12.80	17.67	4.90	1.92	0.12	0.67	3.04	3.96	5.20	0.26	0.96	0.01	0.08	0.05
MA15Z7	11.64	16.04	4.10	1.75	0.38	0.62	2.76	3.25	5.95	0.27	1.22	0.00	0.11	0.61
Maize stover based rations														
MA15Z8	12.05	17.68	5.56	1.81	0.22	1.13	2.92	3.75	5.20	0.27	0.88	0.01	0.07	0.05
MA15Z9	14.53	23.43	4.25	2.18	0.40	0.40	3.46	4.08	4.62	0.31	1.11	0.00	0.08	0.05
MA15Z10	13.02	19.67	3.69	1.95	0.31	0.31	3.14	3.79	4.47	0.24	1.01	0.00	0.07	0.05
MA15Z11	11.39	16.04	4.19	1.71	0.41	0.69	2.89	3.42	5.83	0.26	0.99	0.00	0.20	0.07
Natural pastures based rations														
MA15Z12	13.48	21.80	4.33	2.02	0.43	0.75	3.18	3.82	4.50	0.29	1.03	0.00	0.07	0.05
MA15Z13	15.42	22.75	5.18	2.31	0.65	0.81	4.03	3.74	4.55	0.44	1.45	0.00	0.10	0.07
MA15Z14	13.78	19.01	4.52	2.07	0.56	0.72	3.64	3.48	4.40	0.36	1.31	0.00	0.09	0.06
Forage mixtures based rations														
MA15Z15	14.25	21.15	5.16	2.14	0.68	1.16	3.68	3.51	4.43	0.40	1.34	0.00	0.09	0.06
MA15Z16	13.99	21.91	5.66	2.11	1.98	3.21	3.48	3.61	4.75	0.37	1.68	0.00	0.09	0.06
MA15Z17	12.86	18.82	4.98	1.93	1.67	2.71	3.21	3.48	4.67	0.31	1.51	0.00	0.08	0.05
MA15Z18	13.76	21.64	5.65	2.07	1.70	2.98	3.33	3.65	4.81	0.38	1.52	0.00	0.08	0.06
MA15Z19	14.30	23.01	4.38	2.15	0.59	0.75	3.43	3.97	4.59	0.31	1.17	0.00	0.08	0.05
MA15Z20	12.79	19.24	3.81	1.92	0.51	0.66	3.11	3.69	4.44	0.24	1.07	0.00	0.07	0.05
MA15Z21	13.26	21.38	4.45	1.99	0.62	1.10	3.15	3.71	4.48	0.29	1.09	0.00	0.07	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 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														
MA20Z1	86.71	1.45	35.44	16.00	0.78	4.43	24.32	22.90	28.00	2.40	9.24	0.00	0.71	0.47
MA20Z2	77.07	1.40	32.07	16.00	0.63	3.56	23.12	23.28	28.00	2.52	9.23	0.00	0.71	0.47
MA20Z3	62.77	1.48	35.77	16.00	1.32	6.80	23.45	23.11	28.00	2.41	9.15	0.00	0.72	0.48
Rhodes grass hay based rations														
MA20Z4	83.99	1.49	41.53	16.00	1.19	6.73	22.86	29.41	37.82	2.31	7.40	0.05	0.62	0.41
MA20Z5	74.92	1.44	35.26	16.00	0.97	5.47	21.77	29.00	35.32	2.20	7.64	0.05	0.63	0.42
MA20Z6	61.05	1.51	41.72	16.00	1.71	8.98	22.10	29.06	37.20	2.37	7.47	0.05	0.63	0.42
MA20Z7	88.30	1.44	30.37	16.00	3.23	5.71	21.23	25.00	47.21	2.37	10.43	0.00	1.01	0.68
Maize stover based rations														
MA20Z8	42.56	1.60	31.61	16.00	0.75	4.25	22.15	27.39	31.30	1.51	7.78	0.00	0.60	0.40
MA20Z9	42.73	1.53	26.32	16.00	0.57	3.25	21.10	27.26	29.55	1.51	7.96	0.00	0.62	0.41
MA20Z10	36.73	1.62	32.73	16.00	1.35	6.88	21.41	27.20	31.24	1.65	7.80	0.00	0.61	0.41
MA20Z11	88.31	1.44	30.37	16.00	3.23	5.71	21.23	25.00	47.21	2.37	10.42	0.00	1.01	0.68
Natural pastures based rations														
MA20Z12	38.85	1.57	35.73	16.00	10.61	16.40	24.03	23.60	28.24	2.90	11.13	0.00	0.65	0.44
MA20Z13	38.31	1.47	34.47	16.00	9.75	15.07	24.30	24.50	30.24	2.70	11.05	0.00	0.64	0.42
MA20Z14	35.43	1.57	37.50	16.00	10.19	17.41	23.79	23.90	29.39	2.92	10.84	0.00	0.65	0.44
Forage mixtures based rations														
MA20Z15	68.36	1.50	41.51	16.00	2.59	8.96	22.83	28.83	37.09	2.29	8.01	0.05	0.63	0.42
MA20Z16	62.58	1.44	35.20	16.00	2.31	7.61	21.74	28.45	34.59	2.18	8.22	0.04	0.64	0.43
MA20Z17	52.15	1.52	41.71	16.00	3.14	11.26	22.08	28.46	36.45	2.35	8.08	0.04	0.64	0.43
MA20Z18	39.62	1.60	32.60	16.00	2.29	6.88	22.21	26.97	31.18	1.57	8.37	0.00	0.61	0.40
MA20Z19	39.90	1.53	27.26	16.00	2.05	5.76	21.14	26.85	29.43	1.56	8.55	0.00	0.63	0.42
MA20Z20	35.00	1.62	32.91	16.00	2.84	9.30	21.22	26.58	30.39	1.73	8.42	0.00	0.63	0.42

[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

Table32b. Expected daily 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														
MA20Z1	14.58	21.12	5.17	2.33	0.11	0.65	3.55	3.34	4.08	0.35	1.35	0.00	0.10	0.07
MA20Z2	15.08	21.12	4.84	2.41	0.10	0.54	3.49	3.51	4.22	0.38	1.39	0.00	0.11	0.07
MA20Z3	14.31	21.12	5.12	2.29	0.19	0.97	3.36	3.31	4.01	0.35	1.31	0.00	0.10	0.07
Rhodes grass hay based rations														
MA20Z4	14.19	21.12	5.89	2.27	0.17	0.96	3.24	4.17	5.37	0.33	1.05	0.01	0.09	0.06
MA20Z5	14.71	21.12	5.19	2.35	0.14	0.80	3.20	4.27	5.20	0.32	1.12	0.01	0.09	0.06
MA20Z6	13.97	21.12	5.83	2.23	0.24	1.25	3.09	4.06	5.20	0.33	1.04	0.01	0.09	0.06
MA20Z7	13.58	19.48	4.13	2.17	3.23	0.78	2.88	3.41	6.41	0.32	1.42	0.00	0.14	0.09
Maize stover based rations														
MA20Z8	13.17	21.12	4.16	2.11	0.10	0.56	2.92	3.61	4.12	0.20	1.02	0.00	0.08	0.05
MA20Z9	13.82	21.12	3.63	2.21	0.08	0.45	2.91	3.76	4.08	0.21	1.10	0.00	0.09	0.06
MA20Z10	13.04	21.12	4.28	2.09	0.18	0.90	2.79	3.55	4.08	0.22	1.02	0.00	0.08	0.05
MA20Z11	13.44	19.48	4.18	2.15	0.46	0.82	2.96	3.50	6.35	0.32	1.28	0.00	0.13	0.09
Natural pastures based rations														
MA20Z12	16.34	25.57	5.84	2.614	1.73	2.68	3.93	3.856	4.62	0.47	1.82	0.00	0.11	0.07
MA20Z13	14.80	21.77	5.10	2.37	1.44	2.23	3.60	3.63	4.47	0.40	1.64	0.00	0.09	0.06
MA20Z14	15.36	24.07	5.76	2.46	1.56	2.67	3.65	3.67	4.51	0.45	1.66	0.00	0.10	0.07
Forage mixtures based rations														
MA20Z15	14.10	21.12	5.85	2.26	0.37	1.26	3.22	4.06	5.23	0.32	1.13	0.01	0.09	0.06
MA20Z16	14.62	21.12	5.15	2.34	0.34	1.11	3.18	4.16	5.06	0.32	1.20	0.01	0.09	0.06
MA20Z17	13.87	21.12	5.79	2.22	0.44	1.56	3.06	3.95	5.06	0.33	1.12	0.01	0.09	0.06
MA20Z18	13.18	21.12	4.30	2.11	0.30	0.91	2.93	3.55	4.11	0.21	1.10	0.00	0.08	0.05
MA20Z19	13.80	21.12	3.76	2.21	0.28	0.80	2.92	3.71	4.06	0.22	1.18	0.00	0.09	0.06
MA20Z20	13.37	21.67	4.40	2.14	0.38	1.24	2.84	3.55	4.06	0.23	1.13	0.00	0.08	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

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 rations														
MA25Z1	87.07	1.48	36.64	16.00	0.71	4.04	22.93	22.19	28.00	3.08	9.16	0.00	0.73	
MA25Z2	78.63	1.47	46.81	22.74	4.49	10.99	22.07	21.45	28.00	3.52	8.94	0.00	0.65	
MA25Z3	65.18	1.51	36.95	16.00	1.19	6.11	22.14	22.36	28.00	3.11	9.08	0.00	0.73	
Rhodes grass hay based rations														
MA25Z4	84.43	1.52	36.37	16.00	1.03	5.85	21.45	28.11	33.25	2.36	7.54	0.05	0.66	
MA25Z5	75.59	1.47	30.52	16.00	0.82	4.67	20.45	27.78	31.00	2.25	7.76	0.04	0.67	
MA25Z6	63.42	1.54	36.46	16.00	1.49	7.81	20.77	27.78	32.64	2.41	7.60	0.04	0.67	
MA25Z7	88.44	1.46	26.40	16.00	2.90	5.22	19.63	23.14	45.79	2.39	10.95	0.00	1.08	
Maize stover based rations														
MA25Z8	45.01	1.62	28.15	16.00	0.66	3.74	21.00	26.47	28.00	1.63	7.85	0.00	0.63	
MA25Z9	43.92	1.54	24.88	16.00	0.54	3.05	20.58	26.81	28.00	1.57	8.00	0.00	0.64	
MA25Z10	39.09	1.63	29.21	16.00	1.20	6.11	20.36	26.31	28.00	1.76	7.88	0.00	0.65	
MA25Z11	89.11	1.48	26.87	16.00	3.01	5.48	20.18	23.83	45.78	2.38	10.33	0.01	1.06	
Natural pastures based rations														
MA25Z12	72.21	1.49	36.85	16.00	1.94	6.12	22.77	22.22	28.00	3.03	9.53	0.00	0.73	
MA25Z13	66.36	1.47	40.55	20.05	5.15	9.91	22.82	22.51	28.00	3.29	9.29	0.00	0.65	
MA25Z14	56.26	1.52	37.17	16.00	2.44	8.24	21.98	22.39	28.00	3.05	9.46	0.00	0.73	
Forage mixtures based rations														
MA25Z15	70.25	1.53	36.32	16.00	2.26	7.80	21.42	27.59	32.58	2.34	8.07	0.04	0.67	
MA25Z16	63.52	1.47	29.56	16.00	1.97	6.35	20.27	27.22	30.00	2.22	8.31	0.03	0.68	
MA25Z17	54.90	1.55	36.42	16.00	2.74	9.80	20.74	27.25	31.96	2.40	8.14	0.04	0.68	
MA25Z18	41.97	1.62	29.15	16.00	2.05	6.12	21.08	26.12	28.00	1.68	8.39	0.00	0.64	
MA25Z19	40.99	1.54	25.88	16.00	1.94	5.45	20.66	26.45	28.00	1.62	8.55	0.00	0.64	
MA25Z20	36.74	1.63	30.23	16.00	2.61	8.52	20.44	25.96	28.00	1.81	8.43	0.00	0.66	

[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 daily 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 rations														
MA25Z1	16.59	24.56	6.08	2.65	0.12	0.67	3.80	3.68	4.64	0.51	1.52	0.00	0.12	0.08
MA25Z2	16.71	24.56	7.82	3.80	0.75	1.84	3.69	3.59	4.68	0.59	1.49	0.00	0.11	0.07
MA25Z3	16.32	24.56	6.03	2.61	0.19	1.00	3.61	3.65	4.57	0.51	1.48	0.00	0.12	0.08
Rhodes grass hay based rations														
MA25Z4	16.14	24.56	5.87	2.58	0.17	0.94	3.46	4.54	5.37	0.38	1.22	0.01	0.11	0.07
MA25Z5	16.71	24.56	5.10	2.67	0.14	0.78	3.42	4.64	5.18	0.38	1.30	0.01	0.11	0.08
MA25Z6	15.91	24.56	5.80	2.55	0.24	1.24	3.31	4.42	5.20	0.38	1.21	0.01	0.11	0.07
MA25Z7	15.65	22.92	4.13	2.51	0.46	0.82	3.07	3.62	7.17	0.37	1.71	0.00	0.17	0.11
Maize stover based rations														
MA25Z8	15.15	24.56	4.27	2.42	0.10	0.57	3.18	4.01	4.24	0.25	1.19	0.00	0.10	0.06
MA25Z9	15.91	24.56	3.96	2.55	0.09	0.49	3.27	4.27	4.46	0.25	1.27	0.00	0.10	0.07
MA25Z10	15.03	24.56	4.39	2.41	0.18	0.92	3.06	3.95	4.21	0.26	1.18	0.00	0.10	0.07
MA25Z11	15.54	22.92	4.18	2.49	0.47	0.85	3.14	3.70	7.11	0.37	1.61	0.00	0.17	0.11
Natural pastures based rations														
MA25Z12	16.45	24.56	6.06	2.63	0.32	1.01	3.75	3.66	4.61	0.50	1.57	0.00	0.12	0.08
MA25Z13	16.71	24.56	6.78	3.35	0.86	1.66	3.81	3.76	4.68	0.55	1.55	0.00	0.11	0.07
MA25Z14	16.19	24.56	6.02	2.59	0.40	1.33	3.56	3.63	4.53	0.49	1.53	0.00	0.12	0.08
Forage mixtures based rations														
MA25Z15	16.05	24.56	5.83	2.57	0.36	1.25	3.44	4.43	5.23	0.38	1.30	0.01	0.11	0.07
MA25Z16	16.71	24.56	4.94	2.67	0.33	1.06	3.39	4.55	5.01	0.37	1.39	0.01	0.11	0.08
MA25Z17	15.82	24.56	5.76	2.53	0.43	1.55	3.28	4.31	5.06	0.38	1.29	0.01	0.11	0.07
MA25Z18	15.17	24.56	4.42	2.43	0.31	0.93	3.20	3.96	4.25	0.26	1.27	0.00	0.10	0.07
MA25Z19	15.93	24.56	4.12	2.55	0.31	0.87	3.29	4.22	4.46	0.26	1.36	0.00	0.10	0.07
MA25Z20	15.05	24.56	4.55	2.41	0.39	1.28	3.08	3.91	4.21	0.27	1.27	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

2.5 Required nutrients in formulated rations

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

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

Nutrients	Daily milk yield levels (kg/cow)			
	10	**15**	**20**	**25**
DM (kg/day)	9.50- 13.60	12.05-16.62	13.04-16.34	15.03-16.71
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 stover.
(2) The major forage supplements were sweet potato vines and leucaena leaves
(3) Among the commercial concentrates and minerals included in the feed list, maize bran, wheat bran, soya bean meal cake, cotton seed cake and stock lime were selected for formulation by the software.
(4) All the feed resources were available for feeding dairy cattle during the wet and dry seasons but at different quantities
(5) A total of 84 rations were developed to produce 10, 15, 20 or 25 kg milk per cow per day.
(6) The minimum forage: concentrate ratio of 43: 57 was comparable to the recommended minimum ration of 40:60. The highest forage: concentrate ration was 78:22.
(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 140.58, 256.45, 307.22 and 350.49 respectively which implies that the average cost of the formulated rations per Kg of milk was KES 15.06 for the dairy ration against price of milk in the County of KES 36.99. Hence, the percentage of the least feed cost against price of milk was 41 percent.
(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) Generally, the natural pastures based rations were less expensive than the other rations for each of the levels of milk yields.
(11) Inclusion of fodder trees and legumes significantly reduced the cost of the dairy rations formulated.
(12) Soya bean meal was superior supplement than cotton seed cake based on the quality and cost particularly for high yielding cows.
(13) 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 composition, digestibility, milk yield and composition, feed conversion efficiency and cost of production in dairy cattle fed some of the formulated dairy rations. The promising dairy rations will be validated under farmer management using lactating cows in Machakos County.

4.0 REFERENCES

Commission on Revenue Allocation (2011). General information and statistics of Machakos County. Kenya: County Fact Sheets. www.crakenya.org

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

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

Microsoft Office Excel (2007). Binary file format (.xlsb) specification. Excel 2007 Binary File Format (xlsb) specification.pdf

National Research Council (1989). Nutrient Requirements of Dairy Cattle. 6th Rev. Ed. National Academy of Sciences, Washington, D.C.

Robinson, P.H. and Ahmadi, A. (2005). PCDAIRY WIN05. Extension Software Support and Distribution. Dept. of Anim. Sci, University of California. Davis, CA 95616, USA. http://animalscience.ucdavis.edu/extension/software/Pcdairy/Windows/

Technoserve, Kenya (2008).The Dairy Value Chain in Kenya. A report for the East Africa Dairy Development Program in partnership with Heifer International, International Livestock Research Institute, American Breeders Society, and World Agroforestry Centre

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