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Seasonal Variations in Types and Nutrient Concentrations of Feedstuffs for Dairy Cattle in Smallholder Farmers in The Eastern Province of Rwanda

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ABSTRACT

This study investigated the type and quality of forages used in smallholder dairy farms in three agro-ecological zones (Mayaga and peripheral Bugesera, Eastern Savanna and Central Bugesera, and Eastern plateau) of the Eastern Province of Rwanda in the four seasons of the year. Representative farms were randomly selected from the beneficiaries of Girinka programme. Daily feed types and quantities were recorded and samples were taken for proximate analysis. The analysis of variance (ANOVA) was used to assess the differences in use and quality between zones and seasons. Twenty-two (22) types of feeds were identified across the three zones and four seasons. Roadside grasses, Napier grass (*Pennisetum Purpureum*), and Kikuyu grass (*Pennisetum clandestinum*) were the only grasses that were used in the three zones throughout the year. However, Leersia grass (*Leersia hexandra*) and Rhodes grass (*Chloris gayana*) were only used during the dry season in Eastern Savanna and Central Bugesera zone. The forages harvested from roadside and weeds were the most used (56.1%) followed by the crop residues (28.7%), while the planted forages, were the second least used forages. The only legume forage identified during the study period was Calliandra (*Calliandra Spp*) which contributed up to 0.16% of the overall dry matter intake (DMI). The DMI was higher ($P < 0.05$) in Eastern Savanna and Central Bugesera and it was lower ($P < 0.05$) during the long dry season. The mean daily DMI in all the three zones was 7.94 kg/day. The nutrient content of forages showed a general variation ($P < 0.05$). However, the calcium content of feedstuffs was generally constant ($P > 0.05$) within the zones throughout the year. To enhance dairy cow productivity in the Girinka programme, there is a need for introducing and promoting new legumes, grasses, and trees in the region to improve feed supply, especially in dry seasons.

Key words: Agro-ecological, Feedstuffs, Forages, Girinka, Nutritive value

INTRODUCTION

Livestock plays a significant role in the socio-economic life of African people by providing food and nutritional security and economic growth. Cattle provide milk and meat, and thus help to improve the nutritional and health status of their owners while serving as a source of income (ILRI, 1995; Swanepoel *et al.,* 2010). Furthermore, cattle provide other services to rural households such as draught power, cultural and social services. In line with these multiple uses of cattle, the government of Rwanda implemented a programme called "Girinka" (one cow per poor family) for poverty alleviation. The Girinka programme aims at improving the livelihood of resource-poor households by providing them with dairy cows for increased milk, meat, and manure production (Rwandapedia, 2017). The programme provides local breeds (Ankole), crossbreeds, and exotic dairy cattle breeds namely Jersey and Friesian to selected poor families (MINAGRI, 2006). However, the major challenge faced by these farmers remains the inadequate year-round supply of good quality forage for the animals.

Feed shortage is the major constraint to improve livestock production in Rwanda. Ruminant production in the country is predominantly based on Napier grass (*Pennisetum purpureum)*, natural pastures, and crop residues (Mutimura and Everson, 2011). However, forage production, such as Napier grass plantation, was challenged by several biotic and abiotic factors, such as diseases and drought, mainly brought by climate change (Kawube *et al.,* 2014). Other factors leading to the reduced supply and quality of fodder in the country

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include rainfall fluctuation, and low soil fertility, thus reducing livestock performance. Part of the solution could be supplementation of forages with maize bran or other protein-rich concentrates. Nevertheless, such concentrates are often considered costly to the resource-constrained smallholder dairy farmers in Rwanda. Furthermore, it was recommended to grow forages in grass-legume mixtures to ensure energy-protein balance for ruminants and an increase in soil fertility through the ability of legumes to fix atmospheric nitrogen (N) in the soil by biological N fixation (Kabirizi *et al.,* 2006). However, smallholder dairy farmers in Rwanda, especially the beneficiaries of the Girinka program, do not possess enough land for food crops and forage production.

Due to the limitations in feed supply, resource-poor families in the Girinka programme utilize any available and accessible feedstuff, leading to the use of low-quality forages which have high cell wall content, low protein content, and consequently low feed intake and digestibility translating to poor animal performance (Jung and Allen, 1995). Past surveys were carried out to determine the use of different forages in smallholder dairy farms in Rwanda (Mutimura and Everson, 2011; Mutimura *et al.,* 2015). However, the existing information is based largely on estimates by the farmers which could be less accurate. Furthermore, there is a lack of information on the seasonal variation in the nutrient content and current use of forages in the different dairy farms in the three agro-ecological zones of the Eastern Province of Rwanda. This study, therefore, investigated the type of forages used and seasonal nutrient variation in smallholder dairy farms through feed monitoring and quality assessment.

MATERIALS AND METHODS

The study was conducted in the three (3) agro-ecological zones (AEZ) of the Eastern Province of Rwanda, namely, Mayaga and peripheral Bugesera (MPB), Eastern Savanna and Central Bugesera (ESCB), and Eastern plateau (EP). The province is in the lowland region of Rwanda, at an altitude range of 800 to1500 M above sea level. Climate is semi-arid type with a bimodal rainfall distribution falling from April to August and October to December, with a total annual average of 832-1140 mm (RMA, 2016). The soils are non-humiferous and acid Oxisols with either sandy or clay structure. The temperatures are warm with a monthly average of 20-21°C. The area has a high population density with an average of 450 persons per km^2 (NISR, 2017).

According to Netherlands Development Organization (SNV) (2008), the Eastern Province has more than 49% of all the cattle population in Rwanda but is challenged by prolonged drought as it is the first region with a high risk of drought (Bazimenyera *et al.,* 2014). Cattle production contributes about 30% of the total household income of which 89% is from the sale of milk. The main cattle breeds kept are crossbreeds between exotic (mainly Jersey, Holstein-Friesian) and local Ankole Shorthorn. Milk production per animal in the area is normally between 3 and 10 kg per day in the dry season, and 5 and 15 kg per day during the wet season. The dominant system of dairy production is a zero-grazing system (Cut and Carry system) (SNV, 2008).

The study targeted smallholder dairy farms in communal cowsheds (CCS). Data was collected from one randomly selected CCS in each agro-ecological zone (AEZ) in the Eastern province of Rwanda. From each selected CCS, 50% of cows were randomly selected with the consent of farmers. The feed was monitored for two (2) weeks in August and November 2018, then in early March and May 2019. August and March are the two dry season months associated with feed scarcity, while November and May are the peaks of the rainy seasons when feeds are more widely available. From each shed, 50% of cows were randomly selected for feed monitoring in zero-grazing. A 50 kg spring scale with units of 0.5 kg was used for weighing feeds given to each selected cow. Refusals were weighed every morning and recorded. The types of feeds offered to cattle during the exercise were identified. Samples of various varieties of feed were pooled separately. For each feeds type, at most five samples were combined to make one sample type. One (1) kg was weighed in each sample type and packed into a plastic bag for later

chemical analyses. Feed samples were dried at 65°C to constant weight and ground to pass through a 1 mm screen and stored for later analysis. Proximate analysis of feed was done by wet chemistry (AOAC, 1995) for organic matter (OM), ash, Kjeldahl N (N × 6.25) and ether extract (EE). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were assayed using standard procedure. Calcium and phosphorus were determined by atomic absorption spectrophotometer. Gross energy (GE) concentrations were determined by bomb calorimetry (C 7000 Isoperibolic, Janke and Kunkel IKA – Analysentechnik, Staufen, Germany). The dry matter supply of each feed resource was estimated from the feed sample's analysis.

Statistical analysis

Data collected were analysed using the Statistical Package for Social Scientist (SPSS) software package (SPSS Ver. 16.0, SPSS Inc., Chicago, Illinois). Descriptive statistics (mean and standard error of means (SEM)) were calculated for daily dry matter intake (DMI), daily feedstuff supply, and nutrients composition. Data were subjected to ANOVA to assess the differences between AEZ and seasons. Tukey's honest significant difference test was used for comparisons post hoc for mean separation. A probability level of P≤0.05 was considered to be statistically significant.

Statistical model:

$$Y_{ijk} = \mu + A_i S_j + (AS)_{ij} + e_{ijk}$$

Y_{ijk}: types and nutrient concentrations of feedstuffs for dairy cattle in smallholder farms, μ: overall mean, Ai: fixed effect of i^{th} agro-ecological zone, S_j: effect of j^{th} season, $(AS)_{ij}$: effect of interaction between agro-ecological zone and season, e_{ijk}: random residual error.

RESULTS AND DISCUSSION

The identified forages were mainly categorized into four groups: Grown forages (Calliandra, Napier grass, Brachiaria, Panicum (*Panicum maximum*) and Rhodes grass), crop residues (maize stover, sorghum straw, bean straw (*Phaseolus vulgaris*), banana leaves, banana pseudo-stem, banana peels, rice straw (*Oryza sativa*), and sweet potato vines) roadside and weed grasses (mixed grasses, Couch grass, Kikuyu grass, Paspalum (*Paspalum spp*), Commelina (*Commelina spp*)), and Marshland and savanna forages (Leersia, Dracaena (*Dracaena afromontana*), Cyperus, and Hyparrhenia (*Hyparrhenia spp*)) (Figures 1 and 2). The daily DMI and the contribution of each forage group to the DMI varied with the season and AEZ.

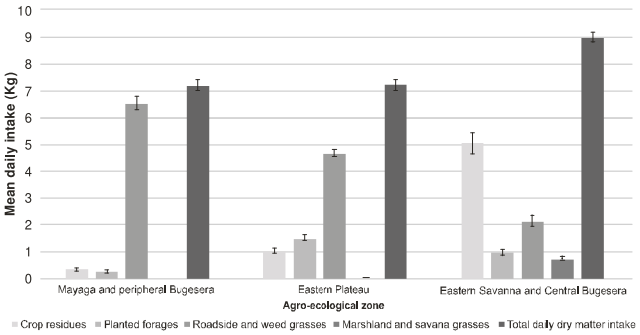

Fig. 1. Use of forage types in three Agro-ecological zones

The DMI was higher (P <0.05) in ESCB compared to MPB and EP (Figure 1). The long dry season had a lower (P <0.05) DMI compared to the two wet seasons (Figure 2). The Roadside and weeds grasses were the most used (P <0.05) forages across all the zones with a yearly contribution of 4.44 kg DMI/day (56.1 %) followed by the crop residues (28.7%). The herbage opportunistically collected from roadsides and couch grass were the most used due to the lack of land for conventional forage growing in the three zones. From the total DMI, the crop residues were most contributing resource in the long dry season contributing up to 49.7% of the DMI (3.59/7.22), while Marshlands and savanna forages were the leastused (P

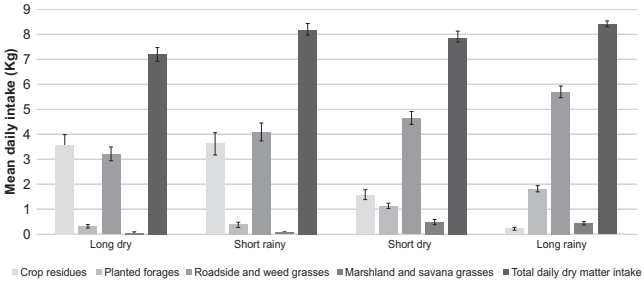

Fig. 2. Use of forage types in four seasons of the year

Table 1: Seasonal and zonal "feed basket" composition

Feedstuff			Daily use (kg DM)							
			Agro-ecological zone			Season				Year
Common name	Scientific name	Vernacular name	MPB	EP	ESCB	LD	SR	SD	LR	
Banana leaves	*Musa spp*	Amakoma	0.00	0.03	0.00	0.02	0.01	0.00	0.02	**0.01**
Banana peels	*Musa spp*	Ibishishwa by'ibitoki	0.00	0.01	0.00	0.01	0.01	0.01	0.00	**0.00**
Banana pseudostem	*Musa spp*	Umutumba	0.12	0.63	0.02	0.52	0.26	0.13	0.10	**0.25**
Bean straw	*Phaseolus vulgaris*	Ibishogoshogo	0.00	0.13	0.32	0.31	0.20	0.10	0.00	**0.16**
Brachiaria	*Brachiaria Spp*	Ifubwe	0.00	0.02	0.01	0.02	0.00	0.00	0.03	**0.01**
Calliandra	*Calliandra Spp*	Kariyandara	0.00	0.04	0.00	0.00	0.00	0.00	0.05	**0.01**
Commelina	*Commelina spp*	Uruteja	0.00	0.12	0.05	0.03	0.03	0.15	0.01	**0.06**
Couch grass	*Digitaria abyssinica*	Urwiri	0.00	3.52	0.87	1.00	1.30	1.33	2.18	**1.45**
Cyperus	*Cyperus latifolius*	Igikangaga, nyagishanga	0.00	0.00	0.10	0.07	0.06	0.00	0.00	**0.03**
Dracaena	*Dracaena afromontana*	Umuhati	0.00	0.03	0.00	0.01	0.02	0.00	0.00	**0.01**
Hyparrhenia	*Hyparrhenia spp*	Umukenke	0.00	0.00	0.50	0.00	0.00	0.26	0.46	**0.18**
Kikuyu grass	*Pennisetum clandestinum*	Umucaca	0.06	1.02	0.07	0.36	0.42	0.30	0.41	**0.37**
Leersia urwuya	*Leersia hexandra*	Urukemba/	0.00	0.00	0.17	0.00	0.00	0.24	0.00	**0.06**
Maize stover (dry)	*Zea mays*	Ibigorigori	0.00	0.17	3.66	1.85	2.24	1.28	0.00	**1.35**
Napier grass	*Pennisetum Purpureum*	Urubingo	0.25	1.41	0.85	0.29	0.39	0.95	1.75	**0.84**
Panicum	*Panicum Maximum*	Panikumu	0.00	0.05	0.00	0.00	0.00	0.02	0.04	**0.02**
Paspalum	*Paspalum spp*	Pasiparume	0.00	0.07	0.00	0.01	0.01	0.01	0.07	**0.02**
Rhodes grass	*Chloris gayana*	Kororisi	0.00	0.00	0.13	0.02	0.00	0.17	0.00	**0.05**
Rice straw	*Oryza sativa*	Ibiceliceli	0.00	0.00	1.05	0.73	0.74	0.00	0.00	**0.37**
Mixed roadside grasses		Imvange	6.60	0.01	1.18	1.82	2.31	2.87	3.18	**2.54**
Sorghum straw	*Sorghum bicolor*	Ibisakasaka	0.00	0.00	0.07	0.04	0.05	0.00	0.00	**0.02**
Sweet Potato vines (fresh)	*Ipomoea batatas*	Imozi y' ibijumba	0.23	0.08	0.00	0.11	0.09	0.07	0.14	**0.10**
Total daily dry matter in take (Kg)			7.26^{a}	7.33^{a}	9.06^{b}	7.22^{1}	8.14^{2}	7.90^{2}	8.42^{2}	**7.92**

MPB: Mayaga and peripheral Bugesera, EP: Eastern plateau, ESCB: Eastern Savanna and Central Bugesera, SD: Short dry, SW: Short rainy, LD: Long dry, LW: Long rainy. The values with different superscript letters in a line are significantly different ($P<0.05$)

<0.05) across all the seasons.

During the study period, 22 types of feedstuffs were identified (Table 1). The Mayaga and peripheral Bugesera (MPB) zone showed a less variation in feed types, recording only five (5) types. The Eastern Plateau (EP) and Eastern Savanna and Central Bugesera (ESCB) zones had 16 and 15 types of feedstuffs, respectively. Roadside grasses, Napier grass, and Kikuyu grass (*Pennisetum clandestinum*) were the only grasses that were used in the three zones for all seasons. While Leersia grass (*Leersia hexandra*) and Rhodes grass (*Chloris gayana*) were only used during the dry season in ESCB zone (Table 1). Twelve (12) out of the 22 were previously reported in the Bugesera District of the Eastern Province (Mutimura *et al.,* 2015) and 6 types in the Northern province of Rwanda (Klapwijk *et al.,* 2014). The feedstuffs reported previously were: Banana leaves, banana peels, banana pseudo-stem (*Musa spp*), Calliandra (*Calliandra Spp*), Commelina (*Commelina spp*), corn plant, couch grass (*Digitaria abyssinica*), cyperus grass (*Cyperus latifolius*), maize stover (*Zea mays*), Napier grass, sorghum stover (*Sorghum bicolor*) and sweet potato vines (*Ipomoea batatas*) (Klapwijk *et al.,* 2014; Mutimura *et al.,* 2015). The low variation in feedstuff observed in Mayaga and peripheral Bugesera (MPB) may be attributed to the weather conditions and comparatively less land per farmer. More variation was observed during the dry season because of the scarcity of conventional forages; hence farmers opt for non-conventional feedstuffs.

The use of individual feedstuff also varied with seasons and agro-ecological zones. The roadside grasses (a mixture of grasses harvested at roadsides) were the most used with a daily supply of 2.54 kg accounting for 32% of total feedstuffs (Table 1). This was followed by the couch grass, maize stover, and Napier grass with 1.45, 1.35, and 0.84 kg, respectively. In the MPB, the top four (4) most used feedstuffs were roadside grasses (6.60 kg), Napier grass (0.25 kg), Sweat potato vines (0.23 kg) and banana pseudo-stem (0.12 kg). In EP, the mostly used feedstuffs were Couch grass, Napier grass, Kikuyu grass, and banana pseudo-stem with 3.52 (48%

Table 2. Nutrient composititon of feedstuff of Mayaga and peripheral Bugesera (MPB)

Forages	N		DM (%)		CP (%)		EE (%)		NDF (%)		OM (%)		ADF %		P%		Ca%		GE (KJ/ Kg)	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Banana pseudo stems	4	4	8	7.1	3.9	4.3	1.5	1.4	68.5	61.6	71.2	74.5	28	25	0.11	0.15	0.54	0.57	16.7	17.4
Kikuyu grass	4	3	19.1	17.2	15.1	17.0	2.7	2.9	65.3	63.1	90	94	39.8	36.1	0.34	0.36	0.26	0.25	18.4	19.2
Napier grass	4	4	17.9	15.7	11.9	10.6	2.1	2.8	65	65.1	92.3	95.5	42.7	39.5	0.15	0.14	0.42	0.41	17.4	17.9
Mixed roadside grasses	4	4	36.5	27.5	8.5	10.4	1.4	2.4	65	57.3	89.7	92.1	45.4	42	0.16	0.19	0.35	0.42	16.9	17.7
Sweet Potato vines	3	3	22.5	17.1	10.5	14.5	4.6	5.4	41.1	38.1	90.2	92.6	34.2	32.7	0.15	0.13	1.1	1.13	18.4	18.9
P-value			0.059		0.193		0.063		0.055		0.001		0.002		0.358		0.216		0.001	

N: Number of combined samples, DS: dry season, WS: wet season, DM: dry matter, CP: crude protein, EE: ether extract, NDF: Neutral detergent fibre, OM: Organic matter, ADF: Acid detergent fibre, P: Phosphorus, Ca: Calcium, GE: Gross energy.

Table 3. Nutrient composititon of feedstuff of Eastern plateau (EP)

Forages	N		DM (%)		CP (%)		EE (%)		NDF (%)		OM (%)		ADF %		P%		Ca%		GE (KJ/ Kg)	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Banana leaves	4	4	17.5	17	9.5	10.5	7.3	7.4	55.7	52.4	88.6	90.5	40.7	39.5	0.15	0.16	0.94	0.91	18.1	18.4
Banana peels	3	2	15.3	15.2	7.2	7	11.5	11.9	42.3	40.4	88	90.1	22.2	22.3	0.14	0.12	0.31	0.34	18.4	18.5
Banana pseudo stems	4	4	6.5	5.9	4	4.1	1.5	1.4	67.5	60.6	75.1	78.2	29.2	25.6	0.12	0.12	0.59	0.64	16.7	17.4
Bean straw	4	4	87.5	56.6	7.1	7.2	1.1	1.4	69.7	66.5	90.2	94	46.7	41.5	0.12	0.15	0.9	0.88	17.9	18
Brachiaria	0	3	-	23.8	-	15.4	-	2.1	-	65.7	-	94.4	-	35.7	-	0.16	-	0.72	-	18.7
Calliandra	0	3	-	30	-	23.5	-	2.5	-	50.6	-	95.5	-	33.3	-	0.24	-	0.7	-	19.2
Commelina	4	3	12	8	12.2	13.2	13.5	11.5	41.2	39.1	78.5	83.3	35.4	34.5	0.21	0.25	1.11	1.01	16.7	18.7
Couch grass	4	4	51.1	43.1	8.1	10.8	1.4	1.3	53.1	50.3	90.1	93.2	36.4	34.3	0.16	0.14	0.37	0.34	17.9	19
Dracaena (Corn plant)	2	3	23.1	21.1	11.2	12.2	4.1	4.4	55.1	50.4	90.3	94.3	35.5	27.6	0.22	0.24	0.26	0.28	17.3	17.9
Kikuyu grass	4	4	21.1	16.3	14.5	16.4	2.7	2.9	65.3	63.1	90	94	39.5	35.5	0.31	0.34	0.27	0.25	18.4	19.2
Maize stover (dry)	4	4	91	-	3.6	-	0.7	-	83.7	-	92.1	-	43.1	-	0.14	-	0.35	-	17.9	-
Napier grass	4	4	17.9	15.7	9.1	9.8	2.1	2.8	73.5	63.5	86.6	90.5	43.9	37.5	0.11	0.13	0.45	0.41	17.4	17.9
Panicum	3	4	59.5	47.5	9.3	9.3	3.8	4.8	87.4	78.4	89.7	93.2	56.8	52.5	0.21	0.22	0.39	0.44	12.6	15.6
Paspalum	3	3	22.7	22.4	10	12.7	2.5	2.7	68.5	62.5	90.6	95.6	44.7	40.2	0.19	0.16	0.31	0.37	18.2	18.7
Mixed roadside grasses	4	4	34.5	28.5	9.2	12.9	1.4	2.4	61	51.2	91	94.3	46.9	42	0.21	0.24	0.33	0.35	16.9	17.7
Sweet Potato vines	3	3	19.2	16.2	11.5	13.5	4.8	5.1	41.7	38.5	88.8	92.7	35.8	32.7	0.17	0.17	1.4	1.3	18.3	18.7
P-value			0.029		0.003		0.407		0.000062		0.000065		0.000073		0.159		0.575		0.003	

N: Number of combined samples, DS: dry season, WS: wet season, DM: dry matter, CP: crude protein, EE: ether extract, NDF: Neutral detergent fibre, OM: Organic matter, ADF: Acid detergent fibre, P: Phosphorus, Ca: Calcium, GE: Gross energy.

of total feedstuffs), 1.41, 1.02 and 0.63 Kg, respectively.

In ESCB, maize stover dominated with daily use of 3.66 kg which accounted for 40.4% of total feedstuffs, followed by roadside grasses (1.18 kg), rice straw (1.05 kg) and couch grass (0.87 kg). In ESCB, Napier grass came in the 5th position with daily use of 0.85 kg (Table 1). Considering the seasons, the results showed a dominance of roadside grass and maize stover in the dry seasons. The results showed that 1.85 kg (25.7% of total feedstuffs) and 1.28 kg (16.2%) in the long dry season and short dry season, respectively, for maize stover, and 1.82 kg and 2.87 kg in the two dry seasons for roadside grasses. The Couch grass is the second most widely used feedstuff during the wet seasons (1.3 and 2.18 kg) after roadside grass that dominated again in the dry seasons with 2.31 and 3.18 kg as a daily use (Table 1). Napier grass was used at a daily rate of 0.29, 0.39, 0.95, and 1.75 kg in the long dry season, short rainy season, short dry season, and long rainy season, respectively. Among the crop residues, maize stover was the most widely used at 1.35 kg accounting for 17.1% of total feedstuffs in the year. Of all the feedstuffs identified in the four seasons, the least used feedstuff was banana peels (0.003 Kg) followed by banana leaves and Dracaena.

During the dry season, farmers in Eastern Savanna and Central Bugesera (ESCB) zone relied on crop residues (52.7%) mainly maize stover as maize is grown as a staple food crop in the region and farmers were trained in forage conservation, resulting in better management of crop residues. The couch grass was mainly used in wet seasons as it is one of the major weeds in Rwanda. In the current study, Napier grass came 4th due to the same reason of unavailability of land. This study was done on Girinka beneficiaries in communal cowshed whose land is less than 0.25 ha. The findings on the use of Napier grass from this study differ from previously reported results which stated that Napier grass was one of the two most widely used grass species in smallholder farmers in Rwanda (Mutimura and Everson, 2011; Mutimura *et al.,* 2013; Mutimura *et al.,* 2015). The reason is that in the current study, targeted farmers had less land, hence they opt for growing food crops than forages. They mostly go for couch grass that is a weed available during the weeding of crops, then for roadside grass mixture that they can get for free and also use crop residues. The results of this study are in agreement with the one previously reported in one district of the Eastern Province. Mutimura *et al.,* (2015) found that more than 90% of farmers in Bugesera district used crop residues and herbage opportunistically collected from roadsides and marshland.

The nutritional characteristics showed a wide variation within types of feedstuffs ($P<0.05$) but a moderate variation within seasons and AEZ (Tables 2, 3, and 4). The crude protein (CP), organic matter (OM), ether extract (EE), gross energy (GE), and phosphorus (P) content were generally higher during the wet season as compared to the dry season ($P <0.05$). The reverse was observed with DM, ADF, NDF, and Ca (Tables 2,3 and 4). However, the calcium (Ca) content varied neither with season nor with AEZ. Dry matter content varied from 6.5% (banana pseudo-stem) to 93.0% (sorghum straw) and from 5.5% (banana pseudo-stem) to 92.8% (rice straw) during dry and wet seasons, respectively.

The crude protein (CP) content also showed wide variation among feedstuffs. The lowest values of CP was reported in banana pseudo-stem. Kikuyu grass had the highest CP of 15.1% among the feedstuffs used during the dry season while Calliandra had the highest with 23.5% CP content in the wet season. Ether extract (EE) varied from 0.6% (maize stover) to 11.5% (banana peels). Banana pseudo-stem showed a lower organic matter (OM) content in both seasons However, the *Cyperus* had a higher OM content in the dry season.

Sweet potato vines showed lower values of NDF in both seasons. The higher value of NDF was found in *Panicum* (87.4%) in the dry season and maize stover during the wet season (82.2%). *Panicum* had the highest values of ADF in both seasons, 56% and 52% during dry and wet seasons respectively. Phosphorus content varied from 0.1% (bean straw) to 0.34% (Kikuyu grass) and from 0.11 (bean straw and rice straw) to 0.36% (Kikuyu grass) during dry and wet seasons,

Table 4. Nutrient composititon of feedstuff of Eastern Savanna and Central Bugesera (ESCB)

Forages	N		DM (%)		CP (%)		EE (%)		NDF (%)		OM (%)		ADF %		P%		Ca%		GE (KJ/ Kg)	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
Banana pseudo stems	4	4	7	5.5	3.5	3.7	1.5	1.4	62.5	58.6	75.1	78.2	27.6	25.8	0.14	0.13	0.56	0.52	16.7	17.4
Bean straw	3	3	88	52.6	7.1	7.2	1.1	1.4	69.7	66.5	90.2	94	43.5	42.6	0.1	0.11	0.85	0.81	17.9	18
Brachiaria	3	0	26.8	-	10.2	-	1.9	-	68.1	-	91.4	-	35.8	-	0.16	-	0.72	-	18.1	-
Commelina	4	0	11	-	12.2	-	13.5	-	41.1	-	78.5	-	35.2	-	0.2	-	1.02	-	16.7	-
Couch grass	4	4	52.1	41.1	8.8	11.8	1.4	1.3	53.1	50.3	90.1	93.2	37.2	34.3	0.11	0.12	0.37	0.39	17.9	18.9
Cyperus latifolius	4	4	26.7	23.7	7	8.6	3.1	3.3	52.5	50.5	94	94.1	52.9	51.1	0.26	0.25	0.33	0.33	17.3	17.6
hyparrhenia	4	4	31.1	27.1	11.4	14.4	5	4.7	67.2	65.2	88.6	91.5	36.5	33.3	0.23	0.25	0.33	0.36	18.9	19
Kikuyu grass	4	4	20.1	18.2	14.8	17.4	2.7	2.9	65.3	63.1	90	94	37.6	35.7	0.34	0.36	0.31	0.3	18.3	19.2
Leersia	3	0	35.2	-	9.5	-	2.1	-	66.2	-	87.2	-	35.1	-	0.18	-	1.44	-	17.4	-
Maize stover (dry)	4	4	93	91	3.8	3.8	0.6	0.7	84.3	82.2	91.4	90.2	41.7	41.2	0.12	0.18	0.31	0.32	17.9	17.8
Napier grass	4	4	17.9	15.7	8.7	9.6	2	2.8	71.5	64.5	86.2	91	40.8	38.6	0.13	0.12	0.48	0.44	17.4	17.9
Rhodes grass	3	0	24.9	-	14	-	2.2	-	75	-	91	-	44.1	-	0.35	-	0.41	-	18.3	-
Rice straw	4	4	92.8	92.8	4.2	4	1.4	1.4	69.1	69.1	82	82	38.5	40.4	0.11	0.11	0.32	0.33	15.5	15.3
Mixed roadside grass	4	4	35	27.5	8.1	12.5	1.4	2.4	58	53	91	94.3	43.6	42	0.13	0.12	0.32	0.3	16.5	17.6
Sorghum stover	4	4	93	92.8	4.6	4.9	1.2	1.2	74.6	76.6	92.5	91.6	46.5	45.9	0.2	0.19	0.29	0.26	18.1	18
P-value			0.070		0.012		0.136		0.005		0.009		0.007		0.352		0.226		0.021	

N: Number of combined samples, DS: dry season, WS: wet season, DM: dry matter, CP: crude protein, EE: ether extract, NDF: Neutral detergent fibre, OM: Organic matter, ADF: Acid detergent fibre, P: Phosphorus, Ca: Calcium, GE: Gross energy

respectively. Lowest values of Calcium content were reported in Dracaena (0.26%) and Kikuyu grass (0.25%) during dry and wet seasons, respectively. The highest values of Ca content were found in Leersia (1.44%) and Sweet potato vines (1.3%) during dry and wet season, respectively. The CP content of Napier grass varied with seasons and AEZ. The CP was 11.9, 9.1, and 8.7% respectively for MPB, EP, and ESCB in the dry season. The CP values were respectively 10.6, 9.8, and 9.6% for MPB, EP, and ESCB zones in the wet season. CP content of mixed roadside grass also showed variation with AEZ, values were 8.5, 9.2, and 8.1% for MPB, EP, and ESCB zones respectively. The energy content showed a moderate variation within the feedstuff, varying from 12.6 to 19.2 kJ/ kg DM for panicum and Kikuyu grass respectively. However, GE was consistently higher ($P<0.05$) during the wet seasons in the three zones.

The observed variation in nutritional characteristics of feedstuffs was expected as they depend on several factors including species, stage of maturity, soil, and climatic factors. The variation of nutrients content with the seasons may be due to the reduced photosynthetic activities of the plants due to harsh environmental conditions and decreased uptake of essential nutrients from the soil during the dry season (Anele *et al.,* 2009). During rainy seasons, there was increased photosynthesis and moisture which increased nitrogen uptake, which could be the reason behind the higher CP content in the wet season (Anele *et al.,* 2009). The findings of this study are in agreement with the findings of Yayneshet *et al.,* (2009) and Woldemariam *et al.,* (2012) who reported lower values of CP with advancement of maturity and during moisture stress. Moreover, this study reported increased values for fibre fraction during the dry season which can be explained by advancement of the age of the plant (Belachew *et al.,* 2013). However, in MPB, Napier grass showed higher CP content during the dry season possibly because farmers harvest Napier grass when it is still very young.

The nutritional characteristics of most the forage species reported in this study lie within the ranges found in other studies on the same species in Rwanda (Mutimura *et al.,* 2015). The couch grass, the most widely used grass, was among the grasses that had the chemical composition lying within the limits of the previous study in Rwanda Province (Mutimura *et al.,* 2015). However, apart from the ADF content, other parameters had values less than 88.4%, 14.6%, and 71.4% respectively for DM, CP and NDF reported in Ethiopia on the same grass (Berhane *et al.,* 2006). Apart from the EE that was higher in this study, the values of DM, CP, OM, NDF, P, and Ca content of the maize stover reported in this study were similar to the values reported from China (Li *et al.,* 2014). Menardo *et al.,* (2015) while working on maize stover in Italy reported similar CP content (36.3 to 56.1 g/kg DM) as observed in this study. However, Kambashi *et al.,* (2014) reported higher values for CP in maize stover. The CP and OM values found in this study for Napier were similar to the ones reported by Mutimura *et al.,* (2015). However, these authors reported higher DM and a lower NDF. A study carried out in the Southern province of Rwanda showed a higher CP (150g/ kg) content as compared to the current study (Klapwijk *et al.,* 2014). The Southern province of Rwanda has a better rainfall level which would be associated with higher nutrient uptake. The CP, OM, ADF, and NDF values reported in the Republic of Congo for Napier, were also similar to the values reported in the current study during the wet seasons (Kambashi *et al.,* 2014).

The DM reported on sweet potato vines is different from that reported by Salehi et al (2014). The DM was higher and NDF was lower, because younger dried forages were used in the previous study, which is not the case in Rwanda where sweet potato vines are harvested as residues at the late after harvest of the tuber. Apart from lower NDF, other parameters were similar to ones reported by Mutimura *et al.,* (2015) in Rwanda. The values of CP for Sweet potato vines were in line with the ones reported in the Southern province of Rwanda (Klapwijk *et al.,* 2014). DM values reported in the current study were within the ranges of reported by Onyango *et al.,* (2019) in Kenya, while they are less than that reported in the Southern Province of Rwanda

(Klapwijk *et al.,* 2014).

CONCLUSION

This study assessed the use of different forages in smallholder dairy farmers of the Eastern Province of Rwanda. The use of cultivated forages was very low in the three zones possibly due to the limited land availability; thus, farmers rather grow food crops than fodder crops. The crop residues were mostly used during the dry season, especially in ESCB zone. Farmers mostly use the mixture of forages harvested from the roadsides and weeds from the food crop plantations. The nutrients content varied with seasons. Legumes forages were least used, hence there is a need for introducing and promoting new legume forages in the region to increase dairy animal performance.

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