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Evaluation of nutritional composition and *in vitro* digestibility of dairy cattle feed resources in Bungoma County, Kenya

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Abstract
The aim of this study was to evaluate the nutritional value of the main dairy cattle feed resources through proximate and *in-vitro* digestibility analyses. The feeds were grouped into 25 diets using a completely randomized design. The chemical analysis was done to determine the nutrient composition. The *in-vitro* organic matter digestibility was determined using the gas production method for all experimental diets. Data collected on proximate analysis, was subjected to the analysis of variance in a completely randomized design using the General linear model procedure of Statistical Analysis System version 9.4. From the results, roughages displayed a diverse range of dry matter content, varying from 904.1 g/kg DM to 936.1 g/kg DM. Super Napier was highest in crude protein content at 149.3 g/kg DM, and neutral detergent fiber content at 733.3 g/kg DM, and maize silage had the lowest at 56.1 g/kg DM. The groundnut residue had the highest crude protein content at 114.6 g/kg DM among the crop residues, while sugarcane tops had the lowest crude protein content at 27 g/kg DM. At 24 and 48 hours of fermentation, the rate of gas production was highest in fodder crops and trees, particularly Lucerne, at 12.7%, and 10% while crop residues such as sugarcane tops had the lowest at 1.60%. This study concludes that fodder trees and legumes have better nutritional profiles, while crop residues are of low quality.

Keywords: Proximate analysis, chemical composition, crop residues, roughages, total mixed rations

Introduction

Approximately 10,000 farmers in Bungoma County, Kenya, rely on the dairy business for their living, and the sector makes a sizable contribution to the regional economy (Were, 2017) [24]. The region's farmers depend substantially on various feed resources to maintain their herds and maximize milk output in dairy cattle farming, a fundamental aspect of agricultural activities. The nutritional value and quality of the feed resources affect herd health, milk production, and farm profitability (Emukule, 2019) [7]. To develop balanced diets that satisfy the dietary needs of dairy cattle, it is critical to comprehend the nutritional composition and digestibility of feed resources (Tona, 2018) [20]. Using locally available feed resources efficiently is crucial for sustained dairy production in Bungoma County (Tona, 2018) [20]. For optimization of feeding and enhancement of animal performance, scientific analysis of feed resources is essential, even if traditional knowledge and empirical observations generally dictate feed selection and management techniques. Proximate analysis and *in-vitro* digestibility experiments are two essential techniques used to determine the nutrient composition, digestibility, and energy content of feedstuffs. Protein, fiber, fat, and ash levels are some of the most fundamental nutritional components of feeds that may be quantified by proximate analysis (Mertens & Grant, 2020) [13]. A practical way to estimate feed digestibility and anticipate nutrient availability is to use *in-vitro* digestibility assays, which mimic the digestive processes that occur in the rumen of cattle. Despite the significance of these analytical methods, more in-depth research needs to be done into the nutritional value of feed supplies for dairy cattle in Bungoma County, Kenya. Past studies have neglected the importance of feed quality in maximizing the well-being and output of dairy animals in favor of more generalized agricultural and socioeconomic considerations. Hence, the primary objective of this research was to determine the nutritional value of the main dairy cattle feed resources used by farmers in Bungoma County, Kenya, through *in-vitro* digestibility and proximate analyses.

Materials and Methods

Feed Sample Preparation

Five hundred grams (500 g) each of the feed samples, namely roughages, concentrates, crop residues, total mixed rations, fodder trees, and legumes, were collected from different farmers in Kaptama and Kitinda milk collection centers (MCCs) and transported in khaki bags to Egerton University's Animal Science Laboratory for nutrient analysis. The feed samples were dried in a draft oven at 105oCand then shredded using a shredder to pass through a 1 mm screen for *in-vitro* digestibility and chemical analysis (AOAC, 2012) [4].

a. Maize stover b. Milled maize stover c. *Saccharum officinarum* tops

Chemical Analysis

The proximate analysis was conducted using standard methods of AOAC (2005) [28]. The Dry matter (DM), (AOAC, 2005: 934.01) [28] organic matter (OM) (AOAC, 2005: 942.05) [28], and crude protein (CP) (AOAC, 2005: 984.13) [28]. Neutral detergent fiber (NDF), and acid detergent lignin (ADL) were determined according to the methods of Van Soest *et al*. (1991) [22].

Rumen Fluid Sampling and *In-Vitro* Digestibility

The *in-vitro* gas production was determined for all experimental diets with strict adherence to the guidelines outlined by Getachew *et al*. (2004) [8]. Rumen liquor from randomly selected cows was extracted using a stomach tube connected to a suction pump before morning feeding and two days before the end of the feeding trial. The liquor was filtered through a two-layered cheesecloth and the fluid was put in a thermos flask where it was continuously flushed with carbon dioxide (CO_2) to remove impurities. The milled samples weighing 200mg were placed in 100ml glass syringes in triplicate. The rumen fluid was mixed with a buffer solution in a 1:2 ratio following which 30ml of the mixture was added to each syringe. A pair of blank syringes only contained 30 ml of fluid- buffer and no feed sample. All the syringes were incubated at the same time in a water bath at 39ºC (controlled thermostatically). The recordings of the gas production were done at 0, 3, 6, 9, 12, 18, 36, 48, 72, and 96 hours by reading the calibration of the piston. The average volume of the gas produced from the blanks was subtracted from the diet-based sample's volume of produced gas. The data on the net volumes of gas was then transferred into Ørskov and McDonald's (1979) [16] model. *In-vitro* organic matter digestibility (OMD) was then determined from the model below: - The exponential equation was –

$$Y = a+b\,(1-e^{-ct}),$$

Where,

Y - gas produced at the time t a+b - potential gas produced (ml), c is the gas production rate constant, and t is the incubation time.

Statistical Analysis

Data collected on proximate analysis, was subjected to the analysis of variance (ANOVA) in a completely randomized design (CRD) using the General linear model procedure of statistical analysis system (SAS, 2002) [17] version 9.0. Means were separated using LSD at ($p<0.05$). The model was as follows:

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

Where:

Y_{ij} = dependent variable μ = overall mean

T_i = effect of the treatment

ε_{ij} = random error term

Results and Discussion

The results for the proximate composition of sampled feed roughages are shown in Table 1. The roughages displayed a diverse range of dry matter (DM) content, varying from 904.1 g/kg DM to 936.1 g/kg DM. The ash content of different roughages varied significantly ($p<0.05$), with panicum having the highest value at 130.8 g/kg DM. Conversely, oats had the lowest amount at 27.0 g/kg DM. Super Napier had the highest crude protein (CP) content at 149.3 g/kg DM, slightly lower than the 84.4 g/kg DM reported by Dombar *et al*. (2022) [6].

The CP content of maize silage was 56.1 g/kg DM, and this can be due to changes in maize quality and harvesting stages, as previously documented by Mandić, *et al*. (2018). The fiber content of different roughages varied, with Super Napier having the highest neutral detergent fiber (NDF) content at 733.3 g/kg DM and maize silage having the lowest at 474.7g/kg DM. ADF ranged from 277.3 g/kg DM to 492.1 g/kg DM for brachiaria and oats, respectively. These results aligned with the findings reported by Adnew *et al*. (2019) [3].

The crop residues exhibited varying chemical compositions, with dry matter (DM) ranging from 888.3 g/kg DM (potato peels) to 942.6 g/kg DM (banana leaves), as shown in Table 2. The ash content of groundnut residues was the highest at 161.9 g/kg DM, while sugarcane tops had the lowest ash content at 62.9 g/kg DM. Similarly, the groundnut residue had the highest crude protein (CP) content at 114.6 g/kg DM, which is lower than the 181.0 g/kg DM reported by Koura *et al*. (2016) [11]. On the other hand, sugarcane tops had the lowest CP content at 27 g/kg DM, which is lower than that reported by Wangila (2021) [23]. The fiber composition of crop residues exhibited significant variation, with bean residues having the highest NDF content at 732.1 g/kg DM. Potato peels had the lowest NDF level at 92.2 g/kg DM. Comparable patterns were noted in ADF and acid detergent lignin (ADL).

Table 1: Chemical composition for roughages in g/Kg^{-1}DM

	Parameters							
Sample	**DM**	**Ash**	**EE**	**CF**	**CP**	**NDF**	**ADF**	**ADL**
Kikuyu grass	932.8^{bcd}	97.8^{gh}	15.0^{jkl}	307.9^{f}	146.4^{e}	693.2^{c}	424.7^{de}	75.5^{ed}
Bracharia	936.1^{abc}	85.4^{ij}	39.7^{de}	340.5^{de}	107.1^{fgh}	617.4^{ef}	277.3^{i}	48.7^{i}
Boma Rhodes	910.2^{jk}	88.4^{i}	16.2^{ijk}	362.0^{bc}	89.7^{ij}	526.3^{h}	390.6^{f}	20.8^{k}
Panicum	936.0^{abc}	130.8^{d}	16.5^{ijk}	357.2^{cd}	101.3^{hij}	598.5^{f}	506.4^{b}	70.6^{ef}
Super Napier	920.8^{fghi}	115.2^{f}	42.0^{de}	379.8^{b}	149.3^{e}	733.3^{ab}	432.0^{d}	63.7^{fg}
Elephant Grass	925.1^{defg}	101.3^{g}	34.2^{ef}	333.5^{e}	86.8^{j}	710.2^{bc}	390.4^{f}	66.7^{fg}
Oat grass	904.1^{k}	27.0^{o}	60.9^{c}	349.9^{cde}	107.6^{fg}	626.5^{ef}	492.1^{bc}	72.3^{def}
Maize Silage	935.9^{abc}	69.7^{k}	19.7^{hij}	341.0^{de}	56.1^{k}	474.7^{ij}	361.7^{g}	64.7^{fg}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

a, b, c, d, e, f, g, i, j, k, l means in the same column with different superscripts are significantly different at p<0.05). DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

Table 2: Chemical analysis for Crop Residues in g/Kg^{-1}DM

	Parameter							
Sample	**DM**	Ash	**EE**	**CF**	**CP**	**NDF**	**ADF**	**ADL**
Bean Residue	938.9^{ab}	124.2^{e}	23.7^{ghi}	490.1^{a}	60.8^{k}	717.2^{abc}	615.1^{a}	105.1^{c}
Millet Residue	915.1^{hij}	116.1^{f}	6.5^{l}	361.0^{bc}	55.6^{k}	658.7^{d}	399.2^{ef}	58.8^{gh}
Groundnut residue	921.1^{fgh}	161.9^{b}	11.0^{kl}	203.4^{i}	114.6^{f}	474.7^{ij}	390.1^{fg}	67.8^{ef}
Potato Peels	912.1^{ijk}	64.9^{l}	11.0^{kl}	115.8^{l}	95.5^{hij}	92.2^{n}	70.5^{n}	11.9^{l}
Maize Stover	930.8^{bcde}	34.0^{m}	8.7^{kl}	336.4^{e}	59.0^{k}	451.7^{jk}	238.1^{j}	35.6^{j}
Sugarcane Tops	935.1^{abc}	62.9^{l}	46.2^{d}	362.5^{bc}	27.8^{l}	645.9^{de}	427.9^{d}	71.6^{ef}
Banana Leaves	942.6^{a}	122.2^{e}	39.2^{de}	139.8^{k}	110.0^{fg}	732.1^{ab}	586.7^{a}	135.2^{b}
Banana stems	928.3^{l}	152.3^{c}	30.5^{fg}	278.4^{a}	5.73^{k}	566.9^{g}	415.8^{def}	80.4^{d}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

a, b,c,d,e,f,g,h,j, k,l,m,n,o,p means in the same column with different superscripts are significantly different at p<0.05). DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

The nutritional features of fodder trees and legumes remained consistent with the findings of previous studies (Castro-Montoya & Dickhoefer, 2020) [5], as shown in Table 3. The samples exhibited DM, ash, crude fiber, and CP levels within the documented range. The CP content varied between 240.7 g/kg DM and 183.4 g/kg DM. These findings emphasize the significance of comprehending the nutritional composition of different feed resources. They also emphasize elements such as plant species, harvesting stages, and planting methods that affect their chemical profiles. This information is crucial for optimizing livestock feeds and ensuring the health and efficiency of animals.

Table 3: Chemical composition of fodder trees, legumes, concentrates, and total mixed rations (g/KgDM)

	Parameter							
Sample	**DM**	**Ash**	**EE**	**CF**	**CP**	**NDF**	**ADF**	**ADL**
Sesbania	925.6^{def}	61.6^{l}	25.2^{gh}	273.0^{h}	240.7^{a}	742.0^{a}	605.1^{a}	185.7^{m}
Leuceana	933.4^{bcd}	50.2^{m}	60.5^{c}	170.1^{j}	201.4^{c}	308.2^{m}	110.1^{m}	20.9^{k}
Calliandra	894.8^{l}	121.7^{e}	14.7^{jkl}	201.6^{i}	228.0^{b}	620.3^{ef}	469.6^{c}	53.7^{ih}
Lucerne	928.6^{cdef}	95.4^{h}	21.2^{hij}	196.1^{i}	195.0^{c}	397.9^{l}	319.4^{h}	67.5^{efg}
Desmodium	904.2^{k}	170.2^{a}	78.3^{b}	293.2^{fg}	197.3^{c}	517.0^{h}	248.5^{j}	66.5^{fg}
Sweet Potato vines	916.9^{ghij}	70.4^{k}	41.9^{de}	188.9^{ij}	183.4^{d}	443.4^{k}	209.5^{k}	34.9^{j}
Maize Bran	932.6^{bcd}	14.7^{p}	90.4^{a}	87.1^{m}	89.1^{j}	483.0^{i}	225.4^{jk}	18.9^{kl}
Dairy Meal	923.6^{efgh}	83.8^{j}	63.1^{c}	172.2^{j}	116.3^{f}	280.3^{m}	152.1^{l}	16.9^{kl}
Total mixed ration	928.7^{cdef}	26.9^{o}	42.2^{de}	116.8^{l}	102.4^{gh}	373.4^{l}	177.1^{l}	20.9^{k}
p-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.16	0.07	0.16	0.35	0.21	0.56	0.52	0.16

a, b,c,d,e,f,g,h, I,j,k,m,n,o,p means in the same column with different superscripts are significantly different at $p<0.05$) DM=Dry matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin, CF=Crude Fiber

In-vitro gas production

Fodder trees and legumes

There were significant differences in gas production among feed resources collected from different farmers. The *In-vitro* gas production and Gas production trends for legumes and fodder trees are presented in Table 4 and Figure 1, respectively. The initial gas production (A) and rates of gas production (C) differed ($p<0.05$) among all the feed resources. The results from *in-vitro* gas production measured from 0 to 96 hours for all the fodder legumes and trees, including leuceana, lucerne, sweet potato vines, calliandra, sesbania, and desmodium. At 24 hours of fermentation, the rate of gas production was highest in lucerne at 12.70, while leuceana recorded the lowest at 5.88%. On the other hand, lucerne recorded the highest OMD. There was no significant difference (p > 0.05) for OMD values for desmodium, calliandra, and sweet potato vines. The observed discrepancies among species in the present investigation may be attributed to the accumulation of fiber, which is influenced by factors such as stage of maturity. This is in line with the fact that the gas production rates (C) and initial gas production (A) varied significantly among the tree resources and feed legumes gathered from different farms. Previous studies have shown that the increased protein and carbohydrate content of legumes allows them to produce more gas than tree fodders (Abraham *et al*., 2023) [1]. The research also backs up the conclusions drawn by Tunkala *et al*. (2023) [21], who found that the chemical composition of substrates significantly affects the parameters of fermentation and the values of the protein percentage in legumes. Previous research has highlighted Lucerne's nutritional superiority for ruminant animals (Wangila, 2021) [23], and this study's results, especially its superior organic matter digestibility (OMD) compared to other fodder resources, are in line with those findings. Although this study did not find a significant variation in OMD among desmodium, calliandra, and sweet potato vines, other factors, including maturity at harvest and processing techniques, can affect the digestibility of these feed resources (Ngunjiri, 2020) [15].

Table 4: *In-vitro* gas production (ml/200mg DM) at 24 and 48hrs and fermentation characteristics of legumes and fodder trees

Sample	24	48	A	B	C	A+B	RSD	% OMD	ME	SCFAs
Calliandra	8.92^{bcd}	1.67^{c}	0.47^{a}	2.80^{b}	0.17^{a}	3.27^{b}	3.35bc	21.31^{c}	7.76^{c}	0.19bcd
Desmodium	10.38^{ab}	1.64^{c}	1.74^{a}	2.49^{b}	0.04^{b}	4.23^{ab}	3.87^{ab}	21.11^{c}	9.09^{a}	0.23^{ab}
Leuceana	5.88^{d}	6.95^{b}	0.21^{a}	4.50^{a}	0.06^{ab}	4.71ab	2.19^{c}	26.04^{b}	7.83^{bc}	0.13^{d}
Lucerne	12.70^{a}	10.06^{a}	0.46^{a}	5.45^{a}	0.10^{ab}	5.91^{a}	4.57^{ab}	28.88^{a}	7.71^{c}	0.28^{a}
Sweet Potato Vines	7.03^{cd}	2.17^{c}	2.81^{a}	2.95^{b}	0.11^{ab}	5.75^{a}	4.91^{a}	21.52^{c}	7.12^{d}	0.15^{cd}
Sesbania	9.56^{abc}	9.02^{a}	0.66^{a}	4.56^{a}	0.09^{ab}	5.21^{a}	3.54^{abc}	28.17^{a}	8.21^{b}	0.21^{abc}
SEM	0.65	0.27	0.61	0.29	0.02	0.39	0.30	0.24	0.08	0.01
p-value	0.0006	<.0001	0.0810	0.0003	0.0440	0.0067	0.0025	<.0001	<.0001	0.0006

A, B, C are constants in the equation (Ørskov & McDonld, 1979) [16]; a, b, c,d Means with the same letter superscript in a column are not significantly different (*p*<0.05). OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation

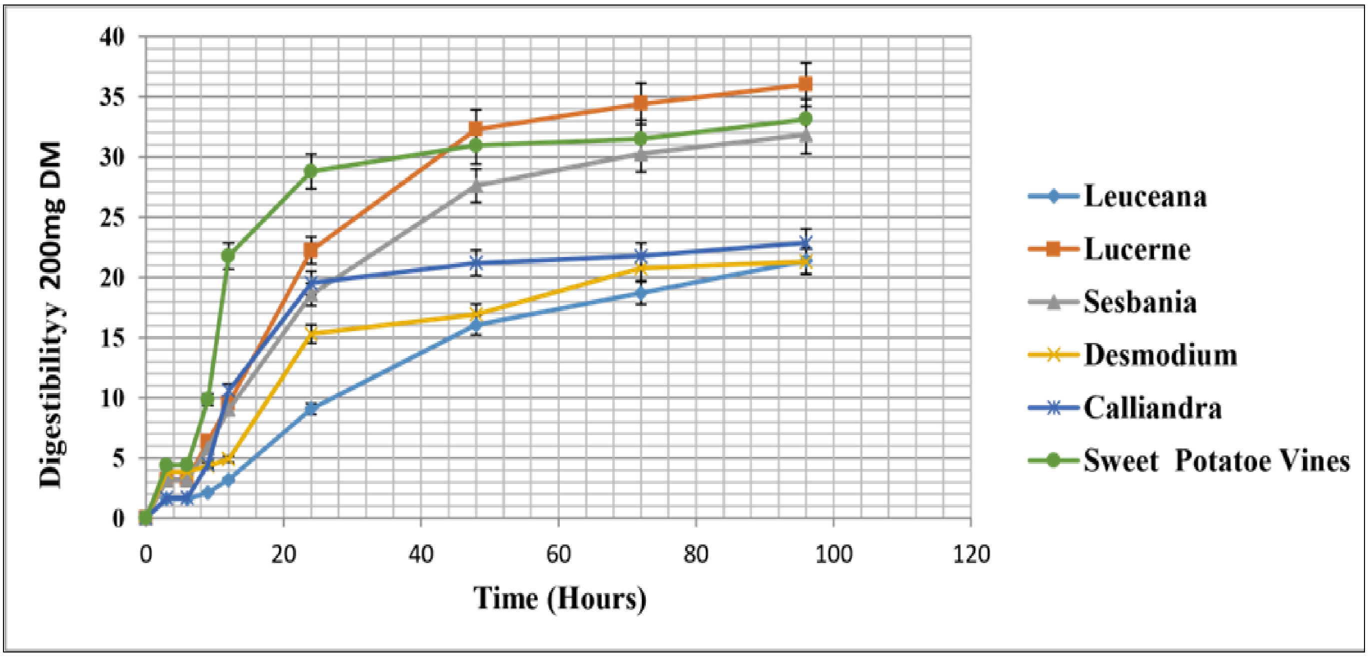

Fig 1: Gas production trends for legumes and fodder trees

Crop Residues

At 24 and 48 hours of fermentation for the crop residues, the rate of gas production was highest in maize stover at 12.27%, followed by the banana stem with 10.59%, sugarcane tops, and millet residue recorded the lowest with 1.60% and 0.54%, respectively, as illustrated in Table 5 and Figure 2. Sugarcane tops and millet residue have comparatively high levels of structural carbohydrates, such as cellulose and lignin, which are less susceptible to degradation by bacteria than non-structural carbohydrates present in other feed components. This structural complexity makes it more difficult for microbes in the rumen to break down these components efficiently, resulting in less gas generation. These results corroborate with Zhao *et al* (2020) [27] who discovered that sugarcane has high levels of cellulose and lignin which make them difficult for microbes to digest. The ME, OMD, and SCFA values (32.10 MJ/kg DM, 32.15%, and 0.27 µmol) observed in this study were higher (*p*<0.05) for maize stover. These values were higher than 7.25-10.10 (ME, MJ/kg DM), lower than 51.87-80.19 (OMD%), and lower than 0.74-1.22 (SCFA, µmol) observed for various forages reported by Yusuf *et al*., (2013) [26], respectively. The gas produced by the maize stover was slightly lower than 16.00 – 22.67 ml/200 mg DM, as reported by Tona *et al*. (2018) [20]. The findings indicated that maize stover possesses better nutritional value when included in ruminant feed compared to bean residue and banana residues. In contrast, sugarcane tops exhibited the lowest nutritional value because of lowered fiber content. Therefore, these diets significantly affect milk production quality, quantity, and the well-being of ruminants; hence, they should not be used as the sole source of feed for dairy animals.

Table 5: *In-vitro* gas production (ml/200mg DM) at 24 and 48hrs and fermentation characteristics crop residues

Sample	24	48	A	B	C	A+B	RSD	OMD	ME	SCFAs
Banana leaves	6.56^{d}	3.81^{cd}	0.42^{ab}	2.41^{cd}	0.12^{bc}	2.84^{cd}	2.30^{ef}	22.65^{cd}	22.65^{a}	0.14^{a}
Banana stem	10.59^{b}	2.23^{de}	0.23^{b}	3.48^{bc}	0.15^{ab}	3.71^{bc}	3.79^{c}	20.90^{de}	20.90^{b}	0.23^{b}
Bean hualms	6.30^{d}	7.87^{b}	0.25^{b}	4.23^{b}	0.06^{cd}	4.48^{b}	2.79^{de}	26.13^{b}	26.13^{c}	0.14^{c}
Groundnut hualms	9.11^{c}	5.90^{bc}	0.25^{b}	4.40^{b}	0.11^{bc}	4.65^{b}	2.97^{d}	24.60^{bc}	24.60^{a}	0.20^{a}
Maize stover	12.27^{a}	14.40^{a}	0.41^{ab}	7.62^{a}	0.07^{cd}	8.03^{a}	5.46^{a}	32.15^{a}	32.15^{b}	0.27^{b}
Millet straw	0.54^{e}	3.26^{d}	0.68^{ab}	1.17^{d}	0.11^{bc}	1.85^{d}	1.53^{g}	21.84^{d}	21.84^{e}	0.01^{e}
Potato peels	12.00^{a}	0.88^{e}	1.24^{a}	2.68^{c}	0.19^{a}	3.92^{bc}	4.79^{b}	19.55^{e}	19.55^{a}	0.26^{a}
Sugarcane tops	1.60^{e}	6.39^{b}	0.92^{ab}	2.91^{c}	0.04^{d}	3.84^{bc}	2.14^{f}	24.58bc	24.58^{d}	0.03^{d}
SEM	0.29	0.48	0.19	0.24	0.01	0.23	0.11	0.44	0.04	0.01
p-value	<.0001	<.0001	0.0201	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

A, B, C are constants in the equation (Ørskov & McDonld, 1979) [16]; a, b, c,d Means with the same letter superscript in a column are not significantly different ($p<0.05$). OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation.

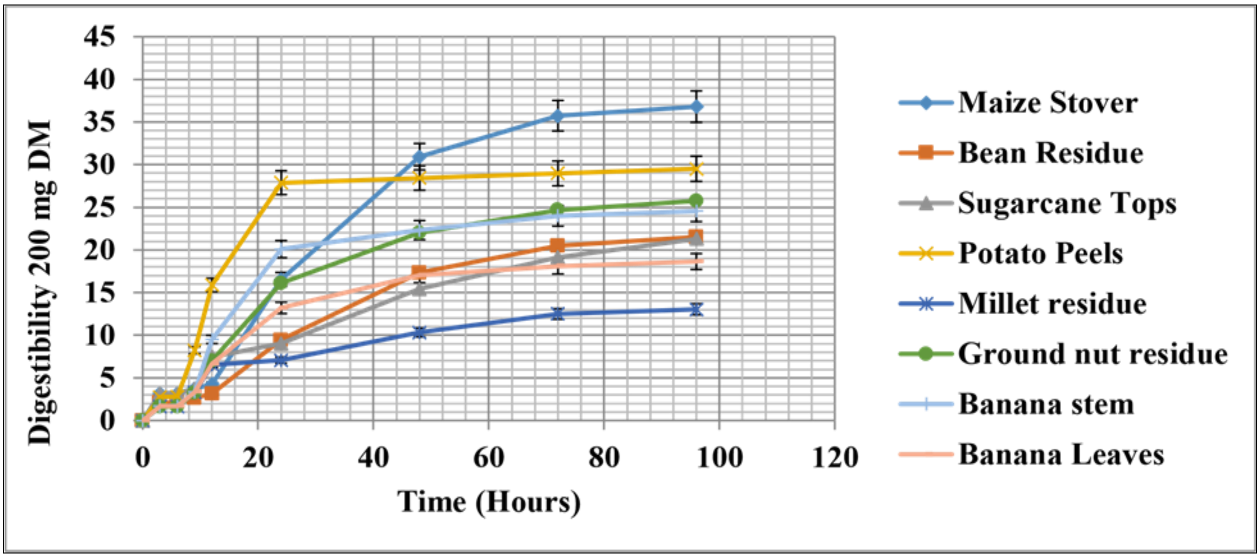

Fig 2: Patterns of *in vitro* cumulative gas production of crop residues

Roughages

Kikuyu grass produced the most gas at 24 hours and 48 hours (11.20 ml/200mg DM, 11.20 ml/200mg DM)), followed by elephant grass (10.19ml/200mg DM), oats (10.98ml/200mg DM), and maize silage (5.86 ml/200mg DM, 8.53ml/200mg DM), as shown in Table 6 and Figure 3. Different roughages have different fermentation properties, such as OMD, ME, and SCFAs. When compared to other roughages, kikuyu grass demonstrated the highest levels of OMD (7.70%), ME (29.67%), and SCFAs (6.53%).

The variation in gas production among the roughages from this study may be due to differences in chemical composition, for instance, high starch and CP but low NDF. These findings are in line with findings by Spanghero *et al*. (2017) [18], who discovered that the effects, at least on early colonization of the feed materials by microbes, will be subsequent substrate fermentation. Kikuyu grass, known for its rapid growth and high productivity, has been consistently reported to exhibit favorable fermentation characteristics in ruminants. This is attributed to its relatively high fiber digestibility, which is reflected in the high organic matter digestibility (OMD) observed in the current study. Additionally, the high levels of metabolizable energy (ME) and short-chain fatty acids (SCFAs) are further consistent with previous research findings (Abu *et al.*, 2022) [2], which demonstrated that Kikuyu grass exhibits superior fermentative properties compared to other roughages. The low gas production in the maize silage reflected the contrasting silage qualities. Differences in the type of substrate available for fermentation greater cell wall content along with decreasing contents of water-soluble carbohydrates and CP in the poorly made maize silage were expected to affect the pattern of fermentation and DM fermentation. These studies corroborate findings by Khan *et al*. (2015) [9], who emphasized the importance of harvesting maize meant for silage at the right stage with the right DM content. Previous studies have also indicated that elephant grass, oats, and maize silage exhibit varying degrees of fermentation properties (Yuan *et al.*, 2013) [25]. While elephant grass and oats demonstrated intermediate levels of gas production and fermentation parameters, maize silage consistently displayed lower values, as evidenced by its lower gas production and comparatively lower OMD, ME, and SCFA levels. This might be due to materials used to make the silage as well as the stage of harvesting as explained by Tauqir *et al (*2008) [19].

Table 6: *In-vitro* gas production (ml/200mg DM) at 24 and 48hrs and fermentation characteristics of roughages for different farmers

Sample	24	48	A	B	C	A+B	RSD	OMD	ME	SCFAs
Brachiaria	8.97^{ab}	9.50^{bc}	5.39^{ab}	5.39^{bcd}	0.07^{cd}	5.42^{bc}	3.49^{ab}	27.88^{bc}	5.87^{b}	0.19^{ab}
Elephant grass	10.19^{ab}	2.68^{d}	4.18^{ab}	4.18^{de}	0.14^{a}	4.15^{cd}	3.22^{bc}	21.48^{d}	5.55^{bc}	0.22^{ab}
Kikuyu grass	11.20^{a}	11.20^{a}	7.13^{a}	7.13^{a}	0.08^{c}	7.70^{a}	4.17^{a}	29.67^{a}	6.53^{a}	0.24^{a}
Maize silage	5.86^{c}	8.53^{c}	4.86^{ab}	4.86^{bcd}	0.06^{d}	5.23^{bcd}	2.53^{c}	26.71^{c}	4.15^{d}	0.13^{c}
Oat grass	10.98^{a}	3.30^{d}	3.64^{ab}	3.64^{e}	0.14^{a}	3.80^{d}	3.84^{ab}	22.16^{d}	6.78^{a}	0.24^{a}
Panicum	8.48^{b}	9.54^{bc}	5.97^{ab}	5.97^{abc}	0.07^{cd}	6.26^{ab}	3.17^{bc}	27.89^{bc}	5.34^{c}	0.18^{c}
Boma Rhodes	10.23^{ab}	10.23^{ab}	6.59^{a}	6.59^{ab}	0.07^{cd}	7.09^{a}	3.85^{ab}	28.47^{ab}	5.35^{c}	0.22^{ab}
Super Napier	9.17^{ab}	2.70^{d}	4.68^{b}	4.68^{cde}	0.12^{b}	4.49^{cd}	2.70^{c}	21.83^{d}	6.77^{a}	0.20^{ab}
SEM	0.49	0.29	0.12	0.31	0.00	0.31	0.15	0.26	0.08	0.01
p-value	<.0001	<.0001	0.0038	<.0001	<.0001	<.0001	<.0001	<.0001	<.001	0.0001

A, B, C are constants in the equation (Ørskov & McDonld, 1979) [16]; a, b, c,d Means with the same letter superscript in a column are not significantly different ($p<0.05$). OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation

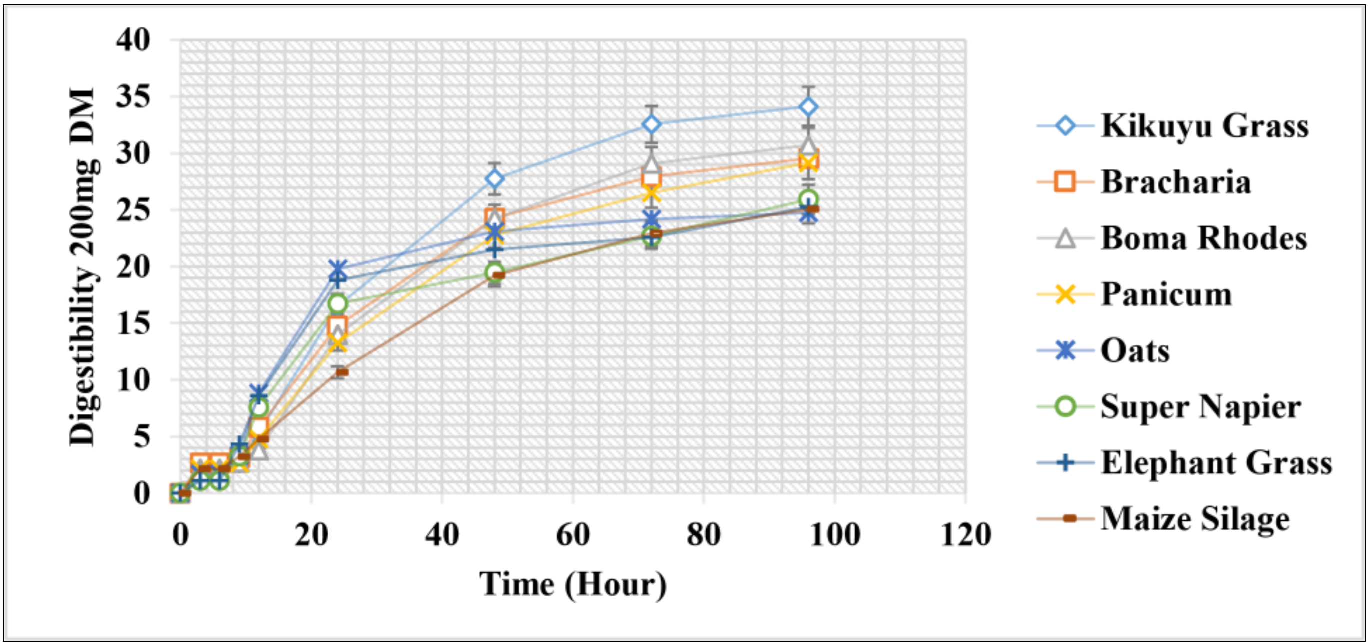

Fig 3: Gas production trends for from different roughages farmers

Concentrates and Total mixed Ration

At 24 and 48 hours, maize bran produced the highest amounts of gas (12.57 ml/200 mg DM and 18.89 ml/200 mg DM), followed by Total mixed ration **(**TMR) (7.89 ml/200 mg DM and 3.68 ml/200 mg DM) as shown in Table 7 and Figure 4. Dairy meal, on the other hand, produced the least gas (7.50 ml/200 mg DM and 0.54 ml/200 mg DM). Maize bran had the highest levels of OMD (9.45%), ME (6.18%), and SCFAs (36.46%). Maize bran's high fermentable carbohydrates and soluble fiber likely contributed to increased gas production.

The variations in fermentation characteristics seen in this study among maize bran, dairy meal, and TMR (comprising maize silage and maize bran) can be partially explained by the disparities in highly fermentable dietary fibers and their fermentation processes (Muqier *et al*., 2023) [14]. In the TMR, *in vitro*, fermentation patterns and product levels mirrored maize silage. These findings align with those of Kidane *et al.* (2020) [10], who discovered that it is possible to argue that the lack of any interaction effects between the type of concentrate feed and the quality of the maize silage in these diets is the result of either a batch culture system artifact or the concentrate feeds' inability to modulate the maize silages differently at the forage-to-concentrate mixing ratio that was utilized in this study. The results on concentrates, particularly the dairy meal used in this study, underscore the importance of having a good quality dairy meal for dairy cows. Additionally, maize silages and their mixtures with concentrate feeds highlight the importance of maize silage quality as modulated by cutting age.

Table 7: *In-vitro* gas production (ml/200mg DM) at 24 and 48hrs and fermentation characteristics of concentrates and TMR from different farmers

Sample	24	48	A	B	C	A+B	RSD	% OMD	ME	SCFAs
Dairy Meal	7.50^{b}	0.54^{c}	0.74^{a}	1.84^{c}	0.20^{a}	2.58^{c}	3.00^{c}	19.65^{c}	6.58^{b}	0.16^{a}
Maize Bran	12.57^{a}	18.89^{a}	-0.27^{b}	9.72^{a}	0.08^{a}	9.45^{a}	6.18^{a}	36.46^{a}	7.93^{b}	0.27ac
TMR	7.89^{b}	3.68^{b}	-0.04^{b}	3.89^{b}	3.26^{a}	3.85^{b}	3.96^{b}	22.48^{b}	5.70^{a}	0.17^{a}
SEM	0.43	0.52	0.12	0.08	1.02	0.15	0.07	0.49	0.11	0.01
p-value	0.0057	<.0001	0.0151	<.0001	0.2513	<.0001	<.0001	0.0001	0.0010	0.0057

A, B, C are constants in the equation (Ørskov & McDonld, 1979) [16]; *a, b, c,d* Means with the same letter superscript in a column are not significantly different ($p<0.05$). OMD: Organic Matter Digestibility; RSD: Residual Standard Deviation; SCFA: Short Chain Fatty Acids; A is the initial gas produced; B is the actual gas produced during DM degradation; A+B is the total gas produced during fermentation.

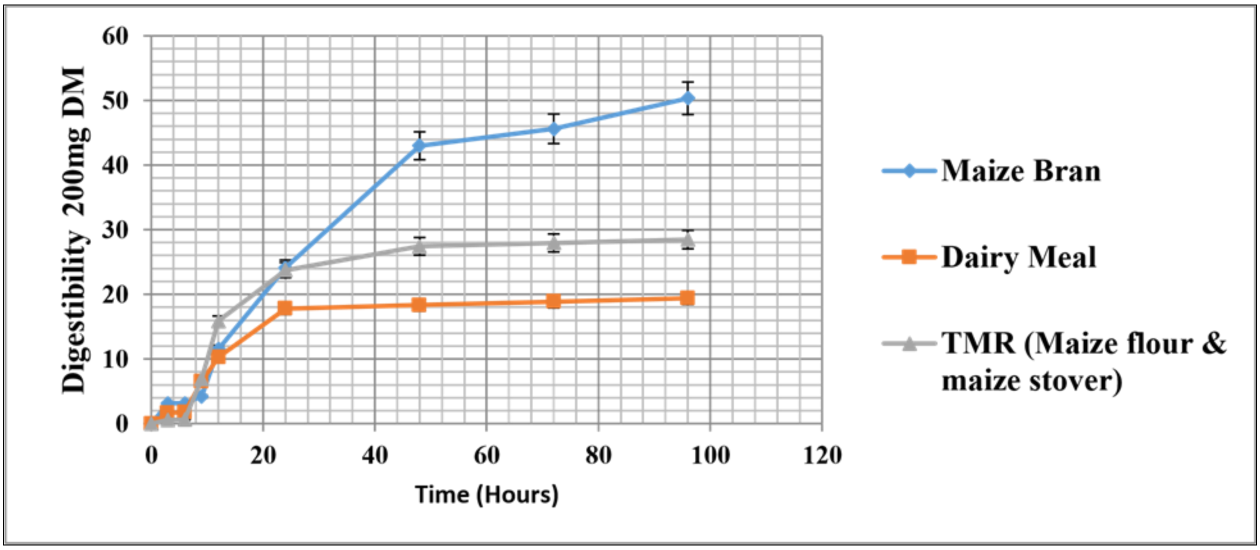

Fig 4: Gas production trends for concentrates and others from different farmers

Conclusion

This study concludes that fodder trees and legumes have better nutritional profiles, while crop residues are of low quality. Roughages on the other hand had moderate nutritional quality. The analysis of these feed sources reveals significant insights into their nutritional composition and implications for dairy farming.

Recommendation

This study recommends the incorporation high-quality fodder trees and legumes into the diet formulations for dairy cattle. The superior nutritional profiles and high crude protein content observed in fodder species like Lucerne, Sesbania, and Calliandra can significantly improve the overall diet quality and support better milk production. Also, optimize the utilization of crop residues by strategic supplementation with concentrate feeds or other protein-rich ingredients. While crop residues like maize Stover exhibited better nutritive value compared to other residues, their inclusion as a sole feed source may not meet the nutritional requirements of dairy cattle. Combining them with supplements can enhance their overall feeding value. Moreover, regularly evaluate the nutritional composition and digestibility of the available feed resources, as variations can occur due to factors like maturity stage, harvesting time, and processing methods.

Conflict of interest

There is no conflict of interest.

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Conflict of Interest

Not available

Financial Support

Not available

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