

Comparative Study on the In – Vitro Digestibility of *Moringa oleifera*, *Gliricidia sepium* and *Blighia sapida*

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Abstract: The chemical composition and in vitro gas production after incubation for 24 hours of *Moringa oleifera*, *Gliricidia sepium* and *Blighia sapida* were investigated. Crude protein values of 14.29%, 18.98% and 17.53% for *Moringa oleifera*, *Blighia sapida*, and *Gliricidia sepium* respectively significantly different ($P < 0.05$), the crude fibre content was 18.57%, 16.23% and 15.89% while the neutral detergent fibre was 46.97%, 45.55% and 45.19% and the acid detergent lignin was 11.76%, 8.43% and 9.20 respectively. The Potential gas production, b from the insoluble fraction of the forages ranged from 17.00ml/200mgDM to 21.33ml/200mgDM. Methane production was highest in *Moringa oleifera* (6ml/200mgDM) and lowest in *Blighia sapida* (4.67ml/200mgDM). Organic matter digestibility, metabolizable energy and short chain fatty acid production value was higher in *Moringa oleifera* than *Blighia sapida*, and *Gliricidia sepium*. The result obtained from this study showed that browse plant are useful supplement in feeding ruminant especially in the dry season.

Keywords: Browse plant, gas production, nutrient composition, feed supplement short chain fatty

1. Introduction

The level of animal protein consumption has a direct influence on the well being and health of human populace. Most Nigerians are poorly fed and suffer from malnutrition due to lack of protein of animal origin. It is reported that the average Nigerian consumed only 4.5g of animal protein per day that is below the FAO recommended value of 35g (1). This could be attributed to the low productivity level of tropical animals which is also affected by availability of feeds. (28) observed that limited supply of animal protein in the tropics is more of the problem of low productivity than small numbers of animals. The low productivity of ruminant livestock is partly a result of the poor nutritional status in terms of quality (44). (51) however observed that native pastures are the most widely available low cost feeds for ruminants in the tropics. Most tropical grass species have low dry matter digestibility and intake (26). Leaves from browse and fodder trees form a major part of livestock feed in tropical countries, and play an especially important role in improving dietary protein (6)

Among these nutritive pastures are tree crops which provide a good source of protein for ruminants most especially in the dry season. Ruminant production benefits from the introduction of adapted browse/legume species into low quality grass dominated pasture. Browse plants with high nutritive values have been successfully fed to small ruminants in alley farming systems (21). Studies have shown that multipurpose trees can be used as cheap protein supplements which can improve voluntary intake; digestibility and general performance of animals fed low quality feeds (27).

Moringa oleifera, a non-leguminous multi-purpose tree, is one of the fastest growing trees in the world, with high crude protein in the leaves (> 20 %) (8; 38). *Moringa* is native to sub-Himalayan regions of India and is now naturalized in

many countries in Africa, Arabia, Southeast Asia, Caribbean Islands and South America (46). It offers a good alternative source of protein to humans and ruminants wherever they thrive (38). Its leaves and green fresh pods are used as vegetables by humans and are rich in carotene and ascorbic acid with a good profile of amino acids, vitamins A, B and C, Ca, Fe and P (31). There has been an increasing interest in the use of moringa as a protein source for livestock (8; 32; 48). (48) reported that moringa foliages are potential inexpensive protein source for livestock feeding. The advantages of using moringa as a protein resource are numerous, and include the fact that it is a perennial plant that can be harvested several times in one growing season and also has the potential to reduce feed cost. *Moringa* can easily be established in the field, and is not affected by any serious diseases in its native or introduced ranges (45).

Gliricidia sepium is a tropical tree legume, which grows abundantly in the southern part of Nigeria (4), although native to Central and South America. It has been shown to have a great potential for ruminant feeding, especially during the dry season in sub Saharan Africa when the natural vegetation is of poor nutritive value (42). This leguminous tree produces a high quality fodder and is a potential substitute of other feed resources (2). Previous records (9; 25) have shown that the leaves contain as much as 20 – 30% CP and about 15% CF. The plant grows vigorously, is drought-resistant and persistent, has good re-growth potentials, and so can be used to provide feed all-year round (9). *Gliricidia sepium* has been described as a suitable feed for ruminants which they can consume in large quantities without deleterious effects on animal performance (14).

Blighia sapida (i.e. ackee) is an evergreen, multipurpose browse plant. It is native to Western Tropical Africa and was introduced into Jamaica in the late 18th century; it has spread to other parts of America but still more widely grown in Jamaica than anywhere else in the world (35). The tree is

one of the home-garden plants in Nigeria mostly grown for its edible aril for human consumption (29). (3) observed that *Blighia sapida* leaves is a feed resource well relish by goats and that it can help to reduce the effect of feed shortage and enhance the poor quality of available grasses and crop residues.

The challenges in using forage as source of feed for animals are estimating its availability and intake and determining whether or not the forage can supply adequate nutrients for maintenance, growth, reproduction and lactation. The *in vitro* gas production method is accurate and predicts feed intake, digestibility, microbial nitrogen supply and animal performance (17). For the past two decades, the technique had been used in advanced countries as an instrument to determine the amount of short chain fatty acids, carbon dioxide and metabolizable energy of feed for ruminants (16; 23).

Methane is an important gas among gases produced by ruminants at fermentation, and has been reported (10) to be an energy loss to the animals and when emitted, it contributes to the destruction of ozone layer. The *in vitro* fermentation technique is capable of quantifying the amount of methane (energy loss) production (22).

The present study was designed to determine the chemical composition and the in-vitro gas production of *Moringa oleifera*, *Gliricidia sepium* and *Blighia sapida* as a dry season feed resource in the tropics.

2. Materials and Methods

The research was carried out at the Cattle, Sheep and Goat Unit of The Teaching and Research Farm of Ladoko Akintola University of Technology, Ogbomoso Oyo State in the derived Savannah Zone of Nigeria. The area is located at 80 10' North latitude and 400 10' East longitudes with annual rainfall of 1270 to 2030 mm, which occurs in 7-10 months with a peak between July and September of the year. The temperature of the area ranges between 28°C to 33°C, with humidity of about 74% all year round except in January when the dry wind blows from the North (41). The in-vitro gas production was carried out at the Animal Science Laboratory, University of Benin.

2.1 Collection of feed sample

Moringa oleifera, *Gliricidia sepium* and *Blighia sapida* was obtained from The Teaching and Research Farm pasture plot of Ladoko Akintola University of Technology, Ogbomoso Oyo State. The foliage used was 4 months old after a cut back at the onset of the dry season. Samples of leaves with tender stems of the forages were weighed, oven dried, and reweighed to determine the dry matter. The dried samples were grinded using a hammer mill into smaller sizes that can pass through a 2mm sieve for laboratory analysis of Crude protein, Crude fiber, Ether extract, and Ash, The proximate analysis was done according to AOAC (2000). Acid Detergent Fiber (ADF), Acid Detergent Lignin (ADL), Neutral Detergent Fiber (NDF) were assessed using the method proposed by (52)

2.2 The *in vitro* gas production technique

Rumen fluid was obtained from three West African dwarf goats using suction tube before the morning feed. The animals were previously fed with concentrate feed and 60% *Panicum maximum* at 5% body weight. The rumen liquor was collected into the thermo flask that had been pre-warmed to a temperature of 39°C from the goats before they were offered the morning feed. Incubation was as reported (34) using 120 ml calibrated syringes in three batch incubation at 39 °C. Into the 200 mg sample in the syringes was introduced 30 ml inoculums containing four layers cheese cloth strained rumen liquor and buffer (containing $\text{NaHCO}_3 + \text{Na}_2\text{HPO}_4 + \text{KCl} + \text{NaCl} + \text{MgSO}_4 \cdot 7\text{H}_2\text{O} + \text{CaCl}_2 \cdot 2\text{H}_2\text{O}$) (1:4, v/v) under continuous flushing with CO_2 . The gas production was measured at 3, 6, 9, 12, 15, 18, 21 and 24 h.

At the end of 24 hours incubation, 4 ml NaOH was added to the substrate in each syringe to determine the methane production as reported by (22). The average of the volume of gas produced from the blanks was deducted from the volume of gas produced per sample.

The volume of the gas produced at intervals was plotted against the incubation time, and from the graph, the gas production characteristics were estimated using the equation; $Y = a + b(1 - e^{-ct})$ described by (43), Where: Y = volume of gas produced at time 't',

a = intercept (gas produced from the soluble fraction), b = Potential gas production (ml/ g DM) from the insoluble fraction, c = gas production rate constant (h^{-1}) for the insoluble fraction (b), t = incubation time.

Organic matter digestibility (OMD %) and metabolizable energy ($\text{MJkg}^{-1}\text{DM}$), were calculated using the following equations according to (34) and the Short chain fatty acid (SCFA) by (23).

$$\begin{aligned} \text{OMD} &= 14.88 + 0.889 * G_v + 0.45 * \text{CP} + 0.65 * A \\ \text{ME} &= 2.20 + 0.136 * G_v + 0.057 * \text{CP} + 0.0029 \text{CF} \\ \text{SCFA} &= 0.0239 G_v - 0.0601 \end{aligned}$$

Where G_v is 24hour net gas production (ml/200 mg DM), CP, CF and ASH are Crude Protein, Crude Fiber (% DM) and Ash respectively

2.3 Statistical analysis

Data were analyzed using analysis of variance (49). Significant means were separated using the Duncan (1955) multiple range F-test. Experimental model of the design is:

$$Y_{ij} = \mu + \alpha_1 + \sum_j j,$$

where Y_{ij} = individual observation, μ = general mean of population, α_1 = treatment effect and $\sum_j j$ = composite error effect.

3. Results

Proximate Composition of the three Browse plant are as shown in table 1. There was significant difference ($P < 0.05$) between the browse plant. It was observed that *Blighia sapida* has highest Crude Protein (CP) 19.36% this was followed by *Gliricidia sepium* (17.79%) while the least value was observed in *Moringa oleifera* (14.89%). Highest value of Crude Fibre (CF) was observed in *Moringa oleifera* (18.21%) followed by *Blighia sapida* 16.78% and 15.96% in *Gliricidia sepium*. It was also observed that *Blighia sapida* produced the highest value 6.28% in Ether Extract (EE) followed by *Gliricidia sepium* 5.44% and 4.27% in *Moringa oleifera*. Ash content of *Blighia sapida*, *Gliricidia sepium* and *Moringa oleifera* was observed to be 11.32%, 10.88% and 8.94 respectively.

Table 2 shows the Fiber fractions composition of three browse plant. The result showed that there were significant difference ($P < 0.05$) between the browse plant except that of NDF. *Moringa oleifera* had the highest NDF (46.97), Acid Detergent Fibre (ADF) 26.85%, (ADL) 11.76% while the least NDF was found in *Gliricidia sepium* (45.19%) and ADF and ADL was obtained in *Blighia sapida* (21.57% and 8.43%).

Gas production characteristics of three browse plants incubated for 24hrs are shown in Table 3, the result shows that the mean values of gas produced from the soluble fraction 'a' has no significant difference between *Blighia sapida* and *Moringa oleifera* but differed in *Gliricidia sepium*. The potential gas production from the insoluble fraction 'b' ranged from 21.33ml in *Moringa oleifera* to 17.67ml in *Blighia sapida* and 17.00ml in *Gliricidia sepium* which were not differed significantly ($P > 0.05$). There were significant differences in potentially degradable fraction of gas production characteristics a+b ($P < 0.05$). Highest value was observed in *Moringa oleifera* 25.67ml followed by 21.33ml in *Blighia sapida* and 18.33ml in *Gliricidia sepium* respectively. The highest volume of gas produced at time 't' was observed to be 12.33ml in *Moringa oleifera* and was followed by *Blighia sapida* 10.67ml while the least was obtained in *Gliricidia sepium* 8.67ml. There was no significant differences in the rate of fermentation 'c' of the three browse plants ($P > 0.05$). The rate of time of fermentation 't' of the three browse plant were significantly different ($P < 0.05$).

Table 4 shows the result of effect of *In vitro* fermentation on Metabolizable Energy, Organic Matter Digestibility and Short Chain Fatty Acid of three browse plant for 24hrs. The result shows that *Moringa oleifera* (6.59) has the highest value in metabolizable energy (ME) and was followed by *Blighia sapida* (6.25) and *Gliricidia sepium* (5.75) respectively. Organic matter digestibility (OMD) highest value was observed in *Moringa oleifera* and was followed by *Blighia sapida* while the least value was obtained in *Gliricidia sepium*. *Moringa oleifera* produced the highest value in Short chain fatty acids (SCFA) and was followed by *Blighia sapida* and *Gliricidia sepium* respectively.

4. Discussion

The proximate composition of the browse plants observed showed that *Blighia sapida* has higher crude protein (CP) content than *Moringa oleifera* and *Gliricidia sepium*. The crude protein of *Blighia sapida* and *Gliricidia sepium* observed were not in agreement with the observation of (37), who observed similarities in the crude protein content of the two browse plants. The least crude protein (CP) was obtained in *Moringa oleifera* (14.89%) but lower than the value reported by (6) which was (19%). It presents a nutrient levels which was superior to the minimum critical levels required for ruminants, and is comparable to other shrubs considered as having a high fodder quality (50). These variations in CP content of the browse forages may be as a result of inherent characteristics of each species related to their ability to extract and accumulate nutrients from the browse living conditions of soil and atmospheric N during the dry season and rainy season as reported by (37). The age at harvest, climate and sampling procedure could also be responsible for variation in the nutrient content. The browse plants here were harvested at four months after cut back at the onset of the dry season.

The crude protein value (14.89-19.36 g/100 g) for the present study was higher than the critical value of 7.7% or 70 g/kg recommended for small ruminants (39) and also higher than the minimum protein requirement of 10-12% recommended by (5) for ruminants.

Ether extract is the lipid fraction, which is a major form of energy storage in the plant. The energy derivable from the plant is what the animal uses for its body maintenance and production. The ash content represents the inorganic (mineral matter) content in a feed.

The crude fiber obtained in this study (18.21%) for *Moringa oleifera* was similar to the value obtained by (36) who obtained a crude fiber value of 19.20% for *Moringa oleifera*. However values obtained for Ether extract and Ash (4.27% and 8.94%) respectively were higher than values obtained by (36) who obtained 2.63% and 5.13% respectively. Variations could be due to age at harvest, location and climatic factors.

The fiber contents (NDF, ADF, Lignin, cellulose and hemicellulose) have implication on the digestibility of plants. The neutral detergent fiber (NDF), which is a measure of the plants' cell wall contents, is the chemical component of the feed that determines its rate of digestion. NDF is inversely related to the plants' digestibility (24; 33). The higher the NDF, the lower the plant's digestible energy. Lignin content of a plant is the most indigestible component of the fibre fractions (24) and its amount will also influence the plant's digestibility. The low lignin value observed in this study is reflective of the age of harvest of the browse plants. It implies that the browse plants would be highly digestible at the harvested age.

In the present study the value of neutral detergent fibre (NDF) and acid detergent fibre (ADF) for *Moringa* (47.85% and 26.79%) does not correlate with the values reported by (6) and (47) which were (18% and 15.9%, respectively). The NDF, ADF and ADL of the browse forages ranges from

44.38% - 47.87%, 21.04 – 26.29% and 8.26 – 11.38% and highest value was observed in Moringa respectively.

The variation among the browse forages in NDF, ADF and ADL may be attributed to planting location as observed by (37) that browse plant in arid and Semi arid zones have higher N than plants in humid zones.

The variation in gas production and potential of gas production between the browse species may be attributed to compositional differences of the browse forages especially CP, Fibre and other anti-nutritional components as reported by (12).

Also high crude protein in feed enhances microbial multiplication in the rumen, which in turn determines the extent of fermentation.

There are many factors that may determine the amount of gas to be produced during fermentation, depending on the nature and level of fibre, the presence of secondary metabolites (11) and potency of the rumen liquor for incubation. It is possible to attain potential gas production of a feedstuff if the donor animal from which rumen liquor for incubation was collected got the nutrient requirement met. Generally, gas production is a function and a mirror of degradable carbohydrate and therefore, the amount depends on the nature of the carbohydrates (16; 19). (22) observed that a decrease in rate and extent of gas production of some shrubs is due to their high contents of lignin and tannins through increasing adverse environmental conditions as incubation time progress. (18) also observed that higher NDF, ADF proportion and condensed tannins (CT) contents can reduce attachment of ruminant animal microbes to feed particles and hence leads to lower gas production.

The result showed that the highest volume of gas produced was observed in *Moringa oleifera* which also had the highest methane production. In most cases, feedstuffs that show high capacity for gas production are also observed to be synonymous for high methane production. Methane production in the rumen is an energetically wasteful process, since the portion of the animal's feed, which is converted to CH₄, is eructated as gas.

The *b* fraction represents the diet that potentially may escape rumen degradation but absorbed in the rumen (40). The low *b* value obtained is an indication of the fibrous nature of the feedstuffs incubated.

The differences in effect of in-vitro fermentation on metabolizable energy (ME), organic matter digestibility (OMD) and short chain fatty acid (SCFA) of the browse forages could be as a result of morphological fraction, environmental factor or maturity stage as also observed by (12).

5. Conclusion

According to the result obtained from this study, it was concluded that browse plant are high in protein content and other nutrient which can be used as feed supplement to shortage of protein and low quality forage grazed by

ruminant animals during the driest part of the year. Therefore, supplementation of browse plant can be used as a major feed resource for ruminant during the dry season to reduce the effect of feed shortage and enhance the poor quality of available grasses and crop residues.

The utilization of browse plants in animal feeding should be encouraged as this will help to reduce the effect of feed shortage and cyclic animal weight changes most especially during the off seasons. It will also help to reduce the effect of climatic changes when more browse plants are being planted.

Table 1: Proximate Composition of *Blighia sapida*, *Moringa oleifera* and *Gliricidia sepium*

Parameters	Crude Protein	Crude Fiber	Ether Extract	Ash
<i>Blighia sapida</i>	19.36 ^a	16.78 ^b	6.28 ^a	11.32 ^a
<i>Moringa oleifera</i>	14.89 ^c	18.21 ^a	4.27 ^c	8.94 ^c
<i>Gliricidia sepium</i>	17.79 ^b	15.96 ^b	5.44 ^b	10.88 ^b
SEM	0.45	0.37	0.19	0.06

abc= Means on the same row with different superscript are significantly different P<0.05

Table 2: Fiber fractions composition of *Blighia sapida*, *Moringa oleifera* and *Gliricidia sepium*

Parameters	Neutral Detergent Fiber	Acid Detergent Fibre	Acid Detergent Lignin	Hemi-cellulose	Cellulose
<i>Blighia sapida</i>	45.55	21.57 ^c	8.43 ^b	23.98 ^a	13.14 ^b
<i>Moringa oleifera</i>	46.97	26.85 ^a	11.76 ^a	20.12 ^b	15.10 ^a
<i>Gliricidia sepium</i>	45.19	23.33 ^b	9.20 ^b	21.87 ^b	14.13 ^{ab}
SEM	0.58	0.20	0.31	0.54	0.29

abc= Means on the same row with similar superscript are not significantly different P>0.0

Table 3: Gas production characteristics of *Moringa oleifera*, *Gliricidia sepium* and *Blighia sapida* incubated for 24hrs.

Treatment	Fermentation characteristics					
	A	a+b	B	C	T	Y
<i>Blighia sapida</i>	3.67 ^a	21.33 ^{ab}	17.67	0.058	10.00 ^a	10.67
<i>Moringa oleifera</i>	4.33 ^a	25.67 ^a	21.33	0.068	7.00 ^b	12.33
<i>Gliricidia sepium</i>	1.33 ^b	18.33 ^b	17.00	0.056	10.50 ^a	8.67
SEM	0.63	2.16	1.96	0.01	0.9	1.26

abc= Means on the same column with similar superscript are not significantly (P > 0.05)

a=intercept (gas produced from the soluble fraction; b=Potential gas production (ml/g DM) from the insoluble fraction; a+b= potentially degradable fractions; c= Rate of fermentation; t= time of fermentation; Y= a + b (1 – e^{-ct}); Volume of gas produced at time 't'.

Table 4: Metabolizable Energy, Organic Matter Digestibility, Short Chain Fatty Acid of *Moringa oleifera*, *Gliricidia sepium* and *Blighia sapida*.

Treatment	ME	OMD	SCFA
<i>Blighia sapida</i>	6.25	49.93	0.57 ^{ab}
<i>Moringa oleifera</i>	6.59	50.22	0.67 ^a
<i>Gliricidia sepium</i>	5.75	46.27	0.50 ^b
SEM	0.29	1.93	0.05

abc= mean on the same column with similar superscript are not significantly ($P>0.05$) different

ME= Metabolizable energy; OMD=Organic matter digestibility; SCFA=Short chain fatty acids.

Figure 1 show the gas produced at different incubation period. The volume of gas produced was plotted against the time of incubation. This graph shows that the highest volume of gas produced for 24hrs was observed in *Moringa oleifera* and was followed by *Blighia sapida* while the least volume of gas produced was obtained in *Gliricidia sepium*.

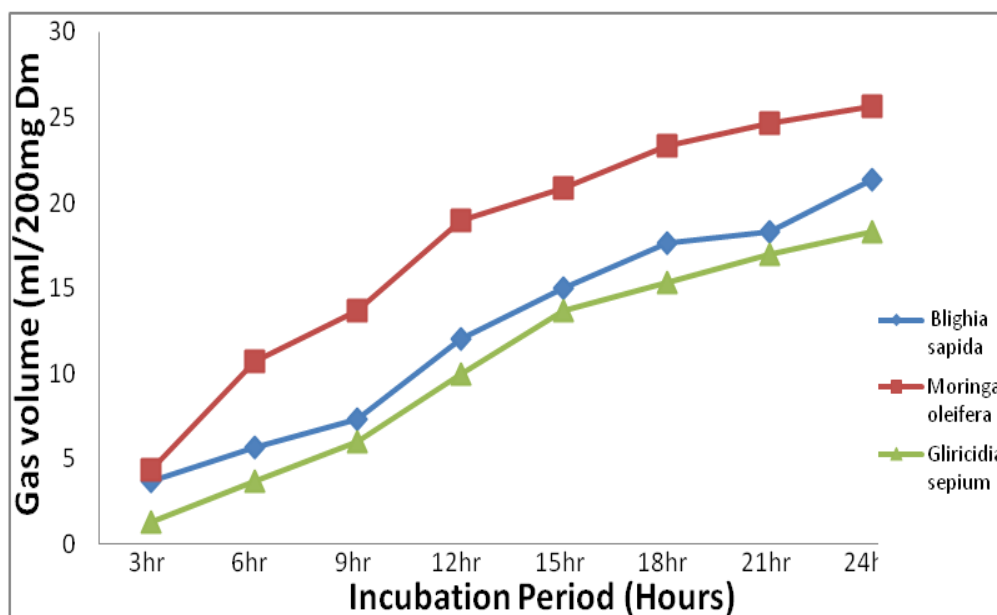


Figure 1: In vitro gas Production of *Blighia sapida*, *Moringa oleifera* and *Gliricidia sepium* incubated for 24 hours

Figure 2 shows the methane production of *Blighia sapida*, *Moringa oleifera* and *Gliricidia sepium*

The highest observed in *Moringa oleifera* and was followed by *Gliricidia sepium* while the least was obtained in *Blighia sapida*.

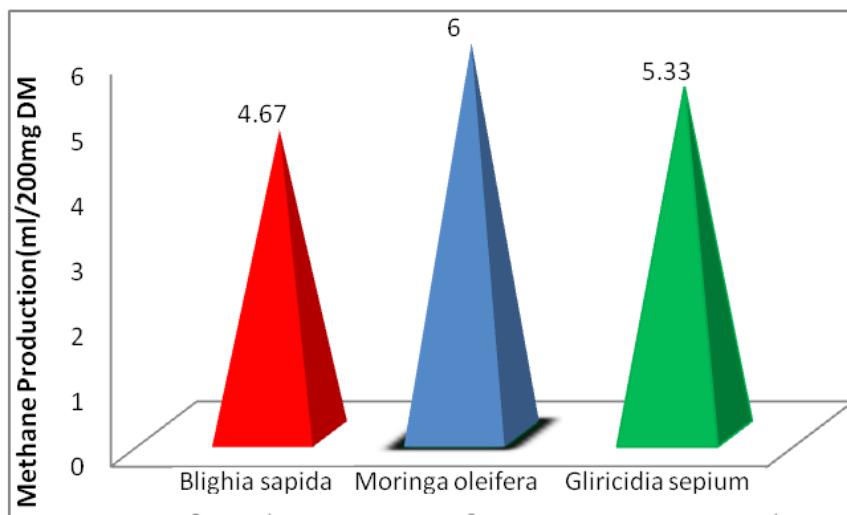


Figure 2: Methane Production of *Blighia sapida*, *Moringa oleifera* and *Gliricidia sepium* incubated for 24 hours

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