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Anaerobic Digestion: An Under-Harnessed Technology to Drive the Nigerian Economy

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ABSTRACT
Anaerobic digestion (AD) is a multi-biochemical process that breaks down organic wastes in the absence of oxygen. It is a naturally driven technology that converts waste to energy and wealth, and can be practised by everyone. Its importance cannot be overemphasised. AD is used to produce energy, organic fertiliser, manage waste, promote good public health and create jobs. Nigeria remains Africa's most populous nation. The continuous production in agricultural and industrial sectors has led to high waste generation. The indiscriminate disposal of waste at dumpsites causes serious environmental pollution. Nigeria, richly blessed with biomass, can adopt the under-utilised, unique sustainable system of AD to overcome some of the crucial environmental and economic issues it encounters. Nigeria, richly blessed with mineral resources such as crude oil, hardly supplies the quantity needed by its people. The high dependence on crude oil has led to environmental pollution and dwindling economic conditions, which have health hazards and untold hardship. The energy sector of the country is not left out. It has been a problem that different governments have been unable to solve. AD, as a viable and cost-effective technology for waste management, presents a practical guide with a multifaceted approach to combating some of these pressing issues in Nigeria. This review, addresses these challenges, which threaten the well-being of Nigerians.

Keywords: Anaerobic Digestion, Economy, Renewable Energy, Nigeria, Waste Management

INTRODUCTION

High population growth can lead to crucial issues of global public health and environmental concern (Sedighi *et al.*, 2022). These issues include the menace of environmental pollution by organic waste (Pavi *et al.*, 2017) and the urgent need for alternative renewable energy sources free of greenhouse gases and effects (Aguilar *et al.*, 2017; Tasnim *et al.*, 2017). Nigeria is not left out in these challenges as it relies heavily on fossil fuels for cooking, electricity generation and transportation (Akinbomi *et al.*, 2014). The lack of sustainable waste management practices in Nigeria also adds to the challenge of environmental pollution (Forbis-Stokes *et al.*, 2016). There is a strong move for measures to convert these organic wastes into resources using alternative and renewable energy sources (Seruga *et al.*, 2018).

Nigeria, located in West Africa on the Gulf of Guinea (Sridhar & Hammed, 2014), has a population of over 237 million people (World Bank, 2025), with a total area of 924,000 km² (Akinbomi *et al.*, 2014). Nigeria is richly blessed with renewable energy sources like biomass and fossil fuels such as crude oil, natural gas, and coal (Adeleke *et al.*, 2023).

Nigeria suffers from unappealing heaps of waste that litter her streets as a result of improper waste management (Sridhar & Hammed, 2014). This has an adverse effect on the health and aesthetic appeal of our cities (Atta *et al.*, 2016). Some of these open waste dumps are burnt, thus releasing toxic fumes. Indiscriminate disposal of waste has other hazardous effects, which include odour emission, breeding of pathogens and disease vectors, and pollution of water sources, which are threats to public health (Riagbayire & Nayem, 2023).

Man's activities basically depend on energy. Like other developing countries, the rural population and urban towns in Nigeria depend on the use of biomass consisting of firewood, charcoal and fossil fuel for energy. This is responsible for serious environmental degradation due to deforestation, pollution, greenhouse gas emissions, poor health, epileptic power supply, economic hardship and heavy work burden on women and children.

The Nigerian economy relies heavily on crude oil, making it vulnerable to any instability in the global oil market (Akinbomi *et al.*, 2014). This dependence on crude oil has its advantages, but the shortfalls cannot be overlooked (Adeleke *et al.*, 2023). Unfortunately, the crude oil dependence has also brought untold hardship to many Nigerians. The youths in the oil-producing areas indulge in oil bunkering, which leads to loss of lives. The price of the commodity keeps skyrocketing, leaving the populace in abject poverty and hardship.

A sustainable system capable of addressing these energy challenges while simultaneously proffering a recycling option for organic waste is needed. The AD process will not only help in waste management but also ensure good health and sustenance of the populace.

This review falls within SDG 7 (Affordable and Clean Energy) and SDG 12 (Responsible Consumption and Production) (Ogunniyi *et al.*, 2026). Globally, AD technology has been adopted as an alternative to clean, renewable energy and has gained international recognition (Nwankwo *et al.*, 2024).

Anaerobic Digestion (AD)

Human overpopulation has led to over-exploitation of traditionally available biomass and an increased need for arable land for food production (Mulinda *et al.*, 2013). Furthermore, collecting traditional biomass such as firewood in forests is risky. It always requires hard labour, so energy generation employing anaerobic digestion (AD) of waste biomass should be a viable alternative.

Anaerobic digestion (AD) (Wainaina *et al.,* 2019; Ukaegbu-Obi *et al.,* 2022) is a complex biological process (Liaquat *et al.,* 2017; Ogunniyi *et al.,* 2026) that converts organic materials in an oxygen-depleted environment (Mirmohamadsadeghi *et al.,* 2021) under a series of metabolic reactions of a synergistic microbial consortium (Wainaina *et al.,* 2019). It utilises various biomass to produce value-added products, such as methane, hydrogen, biofertiliser (Hassanein *et al.,* 2021) and volatile fatty acids (Patel *et al.,* 2021). AD is a technology that offers sustainable approaches and solutions by producing renewable biogas and nutrient-rich digestate (Zielińska & Bułkowska, 2024).

Anaerobic digestion (AD) is a complicated but sensitive process that involves diverse collaborative microorganisms that function under optimum operational physicochemical conditions (Hagos *et al.,* 2017; Ukaegbu-Obi *et al.,* 2022). AD is a very economical, environmentally friendly solution for solid waste treatment (Yin *et al*., 2021). It aids in greenhouse gas emissions reduction (Uddin *et al.,* 2021). It is considered to be one of the most favourable processes for biofuel production from biomass (Rabii *et al.,* 2019). AD process undergoes four sequential stages, which are hydrolysis, acidogenesis, acetogenesis, and methanogenesis (Ukaegbu-Obi *et al.,* 2022). Many studies have been carried out on the anaerobic digestion process for biogas production using different organic matter as mono-substrates (Hagos *et al.,* 2017) and multiple substrates (Ibrahim *et al.,* 2025).

AD is a commercial reality for a range of wastes, but anaerobic digestion of a single waste may be associated with certain drawbacks. These drawbacks include nutrient imbalances, rapid acidogenesis, poor buffering capacity, high ammonia nitrogen concentration, and inhibition of long-chain fatty acids, which can impede methanogenesis. The inhibition of methanogenesis leads to severe instability and process disruption (Rabii *et al.,* 2019). However, anaerobic digestion is used to produce biogas, but due to its complex nature, it remains inefficient and unproductive (Anaya-Menacho *et al.,* 2022). Increasing the production of biogas not only supports the Global Climate Action Plan's goal of cutting methane emissions but also, it increases energy independence and security, reduces offensive odours, improves water quality and aids in producing biofertilizer (USDA & USDOE, 2014; Ukaegbu-Obi *et al.,* 2023).

Anaerobic Co-Digestion

Anaerobic co-digestion is the combined treatment of various feedstock wastes (Olojede *et al.,* 2018) with complementary characteristics, a promising method for both energy and material recovery (Maragkaki *et al.,* 2018), which could be a more sustainable waste management solution (Mu *et al.,* 2020). It is superior to conventional anaerobic digestion (Rabii *et al.,* 2019), thus resulting in high productivity of biogas when compared with mono- or single fermentation processes.

Co-digestion of agricultural by-products with livestock manure and food waste is a promising process for biogas production and environmental protection (Maragkaki *et al.,* 2018; Yang *et al.,* 2025). Some challenges of anaerobic digestion have been addressed by co-digestion of more than one feedstock (Kainthola *et al.,* 2019).

The advantages of co-digestion are better digestibility, enhanced biogas production/methane yield arising from the availability of additional nutrients, as well as more efficient utilisation of equipment and cost-sharing (Manoni-Mshandete & Parawira, 2009; Neshat *et al.,* 2017; Olojede *et al.,* 2018; Ibrahim *et al.,* 2025; Victor *et al*., 2026). Other benefits include: process stabilisation improvement, inhibitory substances dilution, nutrient balance, and accomplishment of the required moisture contents in the digester feed (Liu *et al.,* 2015; Sumardiono *et al.,* 2017; Niya *et al.,* 2026). Co-digestion of food waste and manure has been observed to enhance biogas production and lead to more stable digestion processes (Muratçobanoğlu *et al.,* 2020). When animal wastes are anaerobically co-digested with plant materials, the plant materials provide large amount of carbon, while the animal wastes give different nutrients and buffering capacity. This results in a better carbon/nitrogen ratio balance (Le Pera & Sellaro, 2026).

Recently, the anaerobic co-digestion process has become an attractive research area in biogas production technology (Awhangbo *et al*., 2020). This co-digestion process indicates the feasibility of anaerobic digestion technology in enhancing biogas production and environmental protection.

Suitable procedures and precautions are highly necessary to obtain a stable and improved co-digestion process (Manoni-Mshandete & Parawira, 2009; Ibrahim *et al.,* 2025). There may be requirements for additional digester equipment depending on the size of the operation, quality and characteristics of the wastes to be co-digested. Additional equipment would mainly be required for homogenisation and mixing of co-substrates, delivery of waste, prevention of excessive foaming and scum layer formation, and removal of sediment from the digester. Furthermore, adequate monitoring of process parameters is necessary to help maintain efficient performance during operation. Monitoring can be performed by measuring the activity of different groups of organisms indirectly, such as measuring the rate of gas production or the accumulation of intermediates of anaerobic degradation; these show the current anabolic and catabolic status of the microbes that are actively present (Rabii *et al.,* 2019; Riagbayire & Nayem, 2023).

Anaerobic Digesters

Anaerobic digesters are engineered containment vessels designed to exclude air and promote the growth of methane-producing bacteria. These are biogas plants where various physicochemical and microbial processes take place (Niya *et al.,* 2024). They are also known as bioreactors, biodigesters or anaerobic reactors (Nkoi *et al.,* 2018).

Several types of anaerobic bioreactors are used worldwide for municipal, industrial, food, agricultural and household waste treatment (Ogejo *et al.,* 2009). These reactors have been grouped into two (Orhorhoro & Erameh, 2019) or three major types (Nkoi *et al.,* 2018). Most often applied are wet digester systems using vertical stirred tank digesters with different stirrer types dependent on the origin of the feedstock (Nizami *et al.,* 2013; Westerholm *et al.,* 2016).

Anaerobic digesters are available in several designs and configurations that are classified based on the dry solids content of the feedstock, the number of phases or stages, the operating temperature, and the method of feeding the substrate (Nizami *et al.,* 2013). Examples include dry batch and dry continuous processes for high-solids substrates, sequential batch processes for OFMSW (organic fractions of municipal solid waste) and UASB (upflow anaerobic sludge blanket) for slurries.

These digester designs have the same principle. The substrates are fed via an inlet pipe directly or after a mixing pit. Feedstock retention times of 20 days and above are used. The biogas formed is collected above the slurry and leaves through an outlet pipe for use. Even a pit in the ground can be used as a digester provided the biogas can be captured (Bond & Templeton, 2011). The design of the digesters is varied based on the geographical location, availability of substrate,

and climatic conditions. This can be seen in the type of digesters used in mountainous regions, they are built to have low gas volume to prevent the loss of gas. It is preferred to have digesters underground in tropical countries due to geothermal energy (Rajendran *et al.*, 2012).

The different types of anaerobic digesters include balloon digesters, fixed dome digesters, and floating-drum digesters. Each type of digester has its own merits and drawbacks with respect to the type of substrate, operating conditions, pre-treatment needs and potential outcomes (Kumar & Samadder, 2020).

There are also different materials for the construction of household digesters depending on the geological, hydrological, and local conditions, including locally available materials (Rajendran *et al.*, 2012). Due to technological advances, different materials that have improved properties and are cheaper are now on the market. Some of these biodigester construction materials include concrete, bricks, steel, iron (Kumar *et al.*, 2015), polyethylene (PE) or polyvinyl chloride (PVC) and fibre-reinforced plastics (FRP) or fibreglass.

Anaerobic Digester Feeding

There are two types of anaerobic digester feeding systems; namely: batch feeding systems and continuous systems.

Batch Feeding System

In the batch system, digesters are filled once with fresh feedstock, with or without the addition of inocula, and sealed for the complete retention time, after which they are opened and the effluent removed (Nayono *et al.*, 2009). Batch systems are often considered "accelerated landfill boxes", although, in fact, they achieve much higher biogas production rates than those observed in landfills. This is because of two basic features. The first feature is that the continuous recirculation of leachate not only allows the dispersion of inoculants, nutrients and acids but also improves the mixing conditions. First, continuous recirculation of leachate not only disperses inoculants, nutrients, and acids but also improves mixing conditions. The second is that the batch system is run at higher temperatures than those normally observed in landfills. Most laboratory research carried out in Nigeria uses the batch feeding system.

Continuous Feeding System

Continuous feeding can accelerate gas production and make it more consistent by feeding the digester small amounts of waste daily. In the continuous process, fresh material continuously enters the tank, and an equal amount of digested material is removed (Gashaw, 2016). In continuous feeding, it is very important to make the reactor size large enough to contain all the materials that will be added during the entire digestion cycle. Continuous digesters differ from batch-type digesters in that they produce biogas without the interfering with loading of substrate and unloading effluent. They are thought to be better suited for large-scale operations (Gashaw, 2016). Some examples of continuous feeding digesters include plug flow, CSTR, anaerobic filters and UASB (up-flow anaerobic sludge blanket) (Shah *et al*., 2015).

Process Operational Parameters Monitored During Anaerobic Digestion (AD)

The different process operating conditions have significant effects on biogas production potential (Nsair *et al.*, 2020). To maintain the anaerobic digestion process and optimum biogas production with the lowest costs, these operational parameters need to be monitored. Several parameters have to be controlled to prevent inhibition of biogas production.

Physicochemical analysis is very important to obtain data about the quality of waste material to be used for biogas production (Okunola *et al.*, 2018) and anaerobic digestion process stability. A number of these operational factors affect microbial growth; this, in turn, affects the process of anaerobic digestion and hence, the biogas yields (Goswami *et al.*, 2016; Ogunniyi *et al.*, 2026). These parameters are pH, temperature, Hydraulic Retention Time, Organic Loading Rate, Volatile fatty acids, Carbon to Nitrogen ratio, Volatile solids, and Total solids.

Inhibitory Factors in AD

Inhibitory factors can be brought about by the presence of heavy metals, antibiotics such as Bacitracin, Flavomycin, Spiramycin, and detergents used in livestock husbandry, which can have an inhibitory effect on the process of methane formation.

Some Laboratory Research Carried Out on Anaerobic Digestion in Nigeria

Anaerobic digestion is multifaceted, thus creating multidisciplinary areas for different research to be carried out. In Nigeria, various studies have been carried out in different laboratories depending on the research gaps and areas of study of the scholars. Others have written reviews on the anaerobic digestion process. All these endeavours aim at proffering solutions to the challenges faced by Nigerians through the anaerobic digestion of biomass.

Some investigations have been carried out using various substrates singly for anaerobic digestion (mono-digestion). Adeyanju (2008) investigated the digestion of cassava peels and pig dung supplemented with wood ash. The digester seeded with wood ash gave a higher yield of biogas of 2,345 cm^3, while digesters seeded with pig dung and cassava peels gave 430 cm^3 and 83 cm^3, respectively. Ifeanyi and Ossai (2014) used animal manure (cow dung) to produce biogas. They concluded in their study that a high quantity of biogas can be produced from cow dung by indigenous microbial consortia. Dahunsi *et al.* (2018) produced biogas from the anaerobic digestion of pretreated and untreated *Chromolaena odorata* shoots. They reported that enhanced biogas production was obtained from the combination of different pretreatment methods of the digested substrate. Aisien and Aisien (2020) produced biogas using cassava waste pretreated with three different chemicals. They studied the anaerobic digestion of cassava peels (fresh and stale) and the applications of different pretreatment chemicals (alkaline and acid buffer solutions) on biogas production and methane yield. Their results showed the cumulative amount of biogas generated as 2,540 cm^3/day. The stale cassava peels and cow dung slurry and the use of NH_4Cl pretreatment chemical gave the best biogas production of 104,961 cm^3 and methane yield of 62.3%.

Others have looked at the co-digestion of various substrates to produce biogas. Some went further to study the co-digestion of substrates using different blend ratios. Adelekan and Bamgboye (2009) compared the production of biogas using cassava peels mixed in selected ratios with major livestock wastes. They recommended a cassava peels–livestock wastes mixing ratio of 1:1 for biogas production. Ofoefule and Uzodinma (2009) studied the anaerobic digestion of blends of cassava peels with some animal wastes—cow dung, poultry droppings and swine dung. Their results showed that the low biogas yield and slow onset of gas production/flammability of digested cassava peels can be

significantly enhanced when combined with animal wastes of the same ratio. The blend with swine dung had the highest cumulative volume of gas production, while that with cow dung and poultry droppings had the fastest onset of gas flammability. Oparaku *et al.* (2013) investigated methane generation using cassava peels blended with pig dung in varying quantities of both wastes. They reported that the slurry blend that had the combination of 30% cassava peels with 70% piggery dung yielded the largest volume of biogas on a cumulative basis. Dahunsi and Oranusi (2013) co-digested food waste and human excreta for biogas generation. Adeniran *et al.* (2014) worked on the production of biogas using poultry and swine dung. They reported that swine dung can produce more biogas than poultry droppings. Ibrahim *et al.* (2015) used various local brewery wastes and their blends with yam peels for biogas production. They reported that brew waste has a very high biogas potential. Onuorah *et al.* (2016) co-digested some livestock wastes, namely cow dung, poultry droppings, and pig manure. They deduced that co-digested livestock waste yielded more biogas than the mono-digestion of the individual livestock waste. They recommended the co-digestion of livestock wastes for enhanced biogas production in Nigeria. Ibrahim and Imrana (2016) carried out a comparative study on the co-digestion of corn cobs, groundnut shells and sheep dung and the co-digestion of groundnut shells and sheep dung. Their findings showed that the co-digestion of corn cobs, groundnut shells and sheep dung gave a higher yield of biogas than the co-digestion of groundnut shells and sheep dung. Ajibola and Oguntibeju (2018) investigated sawdust and cassava peels, co-digested with cow dung as a means of generating biogas, and an environmentally friendly waste disposal method. Olojede *et al.* (2018) in their study reported biogas yields from co-digestion of pawpaw peels, potato peels and sunflower leaves with cattle dung. Ojo *et al.* (2018) investigated the synergistic effect of co-digesting different mix ratios of water hyacinth and pig dung for biogas production. They obtained the highest ultimate biogas yield of 9.5 L with the mix ratio of 3 water hyacinth: 7 pig dung. Anika *et al.* (2019) determined the potential of biogas production from different fruit wastes: mango, pawpaw and watermelon and their combinations. However, they reported the highest biogas yield of 4,348 cm^3 from the anaerobic digestion of the combined fruit wastes.

Some have worked on enhanced biogas production and optimisation. Ilaboya *et al.* (2010) investigated the co-digestion of cassava peels with other plants' waste while studying the effects of alkaline pretreatment on biogas production. The results they obtained showed that the addition of different strengths of caustic improved gas yield from 1 to 3% wt/wt sodium hydroxide solution; however, they observed a decrease with 5% wt/wt sodium hydroxide treatment. Uzodinma *et al.* (2011) carried out a comparative study on biogas production by blending maize bract with varied ratios of biogenic wastes such as pumpkin pod, cow and swine dung. Their findings were that the maize bract–pumpkin pod–cow mix showed the best result in the onset of flammable gas production; however, the maize bract–swine mix produced the highest volume of biogas although it had the longest waiting period before flammable gas was produced. Hence, Uzodinma *et al.* (2011) opined that blending maize bract with these biological wastes led to enhanced biogas production. Owamah *et al.* (2014) investigated the optimisation of biogas production and quality from chicken droppings by anaerobic co-digestion with *Cymbopogon citratus*. They observed higher biogas volumetric yield from chicken droppings when digested alone; notwithstanding this, the co-digestion of chicken droppings with *C. citratus* had better gas quality with respect to the methane content present and cooking rate. Okeh *et al.* (2014) used rice husks supplemented with trace elements and nitrogen sources for enhanced biogas production. They reported that sources of nitrogen, water dilution, initial pH, and heavy metals (Zn^{2+}, Ni^{2+} and Cu^{2+}) were factors that affected digester performance. They obtained 1:6 w/v as the best feed-to-water dilution ratio, which gave a biogas yield of 382 mL/day. Meanwhile, they opined that excess water dilution discouraged bacterial cluster formation. This led to a decrease in biogas production. The best biogas yields obtained in their study were 357, 279, and 159 mL/day, which were obtained at pH 7, with poultry droppings supplementation and Ni^{2+} (100 ppm) addition.

Some works have also been carried out on the fabrication and design of simple digesters for biogas production in Nigeria. Olaniyan *et al.* (2017) worked on the construction and design of a simple reactor for biogas production using cassava peels and cow dung. They were able to produce biogas using the simple reactor constructed. They reported an optimum yield of biogas at a pH of 6.80 and an average substrate temperature of 32 °C. Nwankwo *et al.* (2017) designed, constructed and evaluated a pilot plastic digester for biogas generation using cow dung and kitchen wastes—cassava peels, yam peels and vegetables. They produced an average biogas yield of 0.601 to 0.505 m^3/day from the anaerobic digestion of the waste using a 3.6 m^3 capacity plastic biodigester. They opined that the average biogas produced could be sufficient to cook for a family of three or four people.

Akintokun *et al.* (2017) studied the microbial dynamics and biogas production during anaerobic digestion of cow dung and rice husk. They used culture-dependent techniques and PCR amplification to identify and characterise the bacteria and fungi involved during the anaerobic digestion of cow dung and rice husk. The research showed that the co-digestion of cow dung and rice husk (CD: RH) gave the best biogas yield, while rice husk produced the least.

Nkoi *et al.* (2018) carried out a study on the design and fabrication of a modified portable digester for biogas production. They constructed a biodigester which possessed a gas collector and a portable gas storage tank, into which safety and control measures were incorporated. They introduced a device (bike pump) to increase the pressure and velocity of the biogas produced to suit modern gas cooker designs. Nyifi *et al.* (2018) designed and developed a simple technique for handling and storing the biogas produced through the anaerobic digestion of cow dung. Nyifi *et al.* (2018) constructed biogas storage using a vehicle tube with the aid of a motorized compressor. They effectively stored 0.41 m^3 of biogas yield in the storage device of 0.6 m^3 capacity.

Aso *et al.* (2019) studied the unit mass of cassava peel biogasification for biofuel generation. They investigated whether the peel resulting from a unit mass of cassava root generated enough energy to process that unit mass of cassava root into the desired food system. Igbum *et al.* (2019) produced biogas from maize chaff, watermelon, and cassava peels and their combination. They reported that biogas yield was enhanced by co-digestion of the combined substrates. Achi *et al.* (2020) worked on enhanced biogas production from cassava wastewater using biochar and zeolite additives and manure co-digestion. They found that co-digesting cassava wastewater with poultry litter with or without biochar in a typical rural cassava processing industry can significantly enhance the valorisation of cassava wastewater by yielding more methane in less time and an estimated profit of >$5000/year, with the creation of valuable fertiliser. Other investigations (Ogundare & Olukanni, 2020) studied the essential oil and biogas potential recovery from lime wastes

by reducing the effect of d-limonene using solid-liquid extraction as a pre-treatment process. They concluded that the findings of their research show that there is a viable recovery option for biogas from lime waste, and this could boost the drive of the government toward alternative sources of energy. Ukaegbu-Obi *et al.* (2022) investigated the anaerobic digestion of cassava peels using cow rumen as inoculum and reported that a mean cumulative gas of 1,203.37 mL was obtained. Akinnate *et al.* (2025) evaluated the anaerobic co-digestion of cow dung, elephant grass and food waste. They reported that there was higher biogas production in anaerobic co-digestion compared to mono-digestion.

MATERIALS AND METHODS

Sample Collection

While the leaves of *Moringa oleifera* (drum stick) and *Vernonia amygdalina* (bitter leaf) were gathered from Anyigba in the Dekina Local Government Area of Kogi State, Nigeria, the bulb of *Allium cepa* (onion), the clove of *Allium sativum* (garlic), and the rhizome of *Zingiber officinale* (ginger) were bought from a nearby market. After that, the samples were brought in a polythene bag to the lab. Mr. Ayegba, O. Sule of the Botany Unit's Herbarium division at Kogi State University in Anyigba, Nigeria, identified the samples before they were analyzed. *Allium cepa*, *Allium sativum*, *Zingiber officinale*, *Moringa oleifera*, *Vernonia amygdalina*, and *Zingiber officinale* have specimen voucher numbers PT-017, PT-018, PT-0318, and PT-0307 respectively.

RESULTS AND DISCUSSION

The results of the analyses of the polyherbal syrup (PHS), including acute toxicity (LD_{50}), in vitro antidiabetic activity, and GC–MS profiling, are presented in Tables 2–5 and Figures 1–9. Tables 2-4 show the LD_{50} results and clinical behavioural signs from the toxicity study. Figures 1–8 present the in vitro antidiabetic activity, while Figure 9 and Table 5 show the GC–MS profile of the polyherbal syrup and the identified phytochemical constituents.

CONCLUSION

The increasing demand for renewable energy compels the exploration of new substrates and the development of new technologies for biogas production in Nigeria. Regarding raw materials for AD, it is preferable to utilise waste streams since, in this way, the process addresses both waste reduction and energy production. In Nigeria, lignocellulosic residues are readily available; however, further development of novel pretreatment technologies is needed to achieve economically viable processes. Anaerobic degradation of organic material requires a well-functioning microbial consortium, and methanogens, which are responsible for methane production within the final step of the digestion process, are known to be the most sensitive ones to process disturbances. Their washout from the system, therefore, should be prevented. The process of anaerobic digestion will not only help build Nigeria's economy by creating jobs and generating revenue, but it will also alleviate the suffering caused by women and children in rural areas who have to fetch firewood. It will also help reduce greenhouse gas emissions. This technology will help keep Nigeria clean. AD will give individuals the opportunity to provide their own energy for cooking, heating, and electricity while simultaneously converting their organic waste into the desired biofertilizer without depending on the government. It is a welcome development, therefore, to steer the Nigerian economy in the right direction.

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