Journal of Agriculture and Forest Meteorology Research
JAFMR, 5(1): 406-413
www.scitcentral.com

ISSN: 2642-0449

Original Research Article: Open Access

Development of BioFuel Fermentation Chamber for Biomass Feedstock

Adewumi IO[*] and Bamgboye AI

[*]*Department of Agricultural and Environmental Engineering, University of Ibadan, Ibadan, Nigeria.*

Received December 13, 2019; Accepted January 06, 2020; Published January 28, 2020

ABSTRACT

Ethanol can likewise be utilized as fuel for compression ignition engines with some certain modifications. The creation and utilization of fuel ethanol can serve an assortment of necessities in the agricultural process, production and distribution. On a network or individual level, ethanol fuel creation is frequently seen as a way to wind up autonomous of acquired powers, to keep cash in the nearby economy and to give a guaranteed fuel supply in case of deficiencies of oil powers. This research work focus on the development of bio-ethanol fermentation chamber for biomass feedstock. The component parts of the chamber include, the pulley, v-belt, impeller, top cover, tank, heater, thermostat, stand and condenser outlet. The materials used were stainless steel, heater, weighing balance, thermometer, electric motor and wood shavings as feedstock. Wood shavings of 0.5 kg were digested using five replicates, which resulted in an average ethanol production of 0.0476 kg and 0.0604 l. A rate of ethanol production of 0.121 l/kg of wood was obtained from this. The sample size of 1.0 kg of wood shavings was also digested using five replicates resulted in an average ethanol production of 0.095 kg and 0.1208 l. This resulted in an ethanol production rate of 0.121 l/kg of wood. While the sample size of 1.5 kg of wood shavings was digested with five replicates, ethanol produced was 0.1438 kg by mass having 0.1822 l by volume. This implies a production rate of 0.121 l/kg of wood. For all the samples used, an average ethanol production rate of 0.121 l/kg of wood was obtained. This figure extrapolates to 121 l of ethanol per tonne of wood. Kuiper et al. noted that a tonne of fresh cassava tubers yields about 150 l of ethanol, while Adelekan obtained 145 l of ethanol per tonne of the cassava root.

Keywords: Fermentation chamber, Bio-fuel, Wood shavings, Biomass, Feedstock

INTRODUCTION

According to Taylor et al. [1] biofuels are vaporous, fluid or strong powers that are acquired from natural materials. These can be plant or creature materials determined. Biofuels vary from non-renewable energy sources in that petroleum derivatives are gotten from organic materials that have been dead for quite a while, though biofuels can be acquired from crisply collected natural materials [2]. Biofuels are by and large isolated into to begin with, second and third era in view of the wellspring of feedstock. Original biofuels are produced using straightforward grain harvests, for example, corn, wheat, sunflower seeds and so forth. They have a noteworthy preferred standpoint of offering net decreases in CO_2 levels, however there are worries about the impact on sustenance costs, and of broad development of huge grounds to produce crops for biofuels creation and the effect this may have on biodiversity, land and soil [3]. Second era biofuels are produced using non-sustenance crops. Non-sustenance sources, for example, lignocellulosic materials are possibly less expensive, in wealth and won't rival nourishment crops. Bamgboye and Oniya [4] has uncovered that the raising costs of oil energizes, the vulnerabilities in their supply and the destruction of worldwide atmosphere caused by their nonstop utilize have revived research interests in the utilization of vegetable oil fills and different biofuels.

Adelekan [5] has seen that the up and coming and unavoidable fatigue of worldwide stores of petroleum products keeps on inspiring logical examinations concerning functional choices which the world can adventure to give vitality. Scores of natural life forms which can be utilized as substrates for biofuel creation have been recognized far and wide. Those utilized for nourishment introduce a hazard to sustenance supply and this requires exploring the vitality capability of non-sustenance biomass.

Corresponding author: Adewumi IO, Department of Agricultural and Environmental Engineering, University of Ibadan, Ibadan, Nigeria, Tel: 2348023821869; E-mail: adexio2010@gmail.com

Citation: Adewumi IO & Bamgboye AI. (2022) Development of BioFuel Fermentation Chamber for Biomass Feedstock. J Agric Forest Meteorol Res, 5(1): 406-413.

Third era biofuel is produced using green growth. Green growth has the ability to deliver a high return of biofuel from generally low information. As indicated by the US Department of Energy, green growth can deliver 30 times more vitality for each section of land than field harvests, for example, soybeans [3]. As of late, there has been a quick development in the US biofuels industry, especially in ethanol creation. In particular, national creation rates have expanded from 1.8 billion gallons to 4.9 billion gallons in the vicinity of 2001 and 2006.

Enthusiasm for the utilization of biofuels continues developing and more exertion are being coordinated towards innovative work of more effective creation techniques. The customary technique for bioethanol creation is bunch aging utilizing yeast (*Saccharomyces cerevisiae*).

The ethanol created is subjected to additionally handling advances which incorporate refining and lack of hydration to evacuate water. The refining step requires huge vitality contribution for warmth and this progression, subsequently represents a significant piece of the handling cost. Due to the inalienable restrictions of the conventional aging procedure (item restraint, warm insecurity of the microorganism and so forth), there is a need to investigate different choices that outcomes in better process financial matters and proficiency. These choices incorporate the utilization of thermally stable microorganisms, for example, thermophilic microscopic organisms which can make due at lifted temperatures. The utilization of thermophilic microorganisms gives the chance to use a more extensive scope of substrates and furthermore complete the aging procedure near the breaking point of ethanol. This prompts another choice which is the idea of concurrent maturation and item partition. By working near the breaking point of ethanol, it can be evacuated consistently into the gas stage by a physical partition process, for example, gas stripping or by applying a gentle vacuum. Constant item expulsion likewise takes care of the issue of item hindrance as the ethanol created amid maturation does not collect to inhibitory level with the goal that it restrains the development of microbial cells. As of now, look into tends to center around enhancing the execution of disengaged parts of the ethanol creation process, for example, feedstock pretreatment, hydrolysis, aging, item recuperation, and so on. Likewise, maturation step includes the change of sugars from hemicellulose and cellulose and a few gatherings have utilized metabolically built microorganisms for the transformation of hexoses and pentoses from the cellulose (glucose) and hemicellulose (discharged by pretreatment) to ethanol.

The most troublesome errand in aging is that the maturation utilizes something like seven to twenty one day before aging can happen. Because of popularity for bio-fuel, there is a requirement for an enhanced innovation choice with a specific end goal to lessen the ethanol maturation period and to energize extensive creation of ethanol. The feedstock utilized as a wellspring of bio-powers has for the most part been corn, cassava, sugarcane which is generally devoured by people. However, keeping in mind the end goal to give elective feedstock which is non-consumable by human, wood shaven was made the utilization of to deliver ethanol.

ETHANOL PRODUCTION

Scientists have unmistakably portrayed that ethanol has a result of maturation. Maturation is a succession of responses which discharge vitality from natural atoms without oxygen. In this utilization of aging, energy is acquired when sugar is changed to ethanol and carbon dioxide. Changing corn to ethanol by maturation makes numerous strides. The starch in corn must be separated into basic sugars previously aging can happen. In prior circumstances, this was finished by biting the corn. This enabled the salivary proteins to normally separate the starch.

Today, this is accomplished by cooking the corn and including the chemicals alpha amylase and glucoamylase. These compounds work as impetuses to accelerate the substance changes. Once a straightforward sugar is acquired, yeast is included. Yeast is a solitary celled parasite that feeds on the sugar and causes the aging. As the organism bolsters on the sugar, it produces liquor (ethanol) and carbon dioxide. In maturation, the ethanol holds a great part of the vitality that was initially in the sugar, which clarifies why ethanol is a magnificent fuel.

Properties of ethanol

The physical properties of ethanol are directed essentially by the nearness of the hydroxyl gathering and its short carbon chain. The hydroxyl aggregate structures hydrogen bonds which makes ethanol less unpredictable than the other natural compound of similar atomic weight. Ethanol-water blends that contain ethanol more than half are combustible and touch off effortlessly. In India, a liquor stove has been produced which keeps running on a half ethanol-water blend **(Table 1)**.

Table 1. Physical properties of ethanol.

Property	Value
Molecular formula	C_2H_6O
Molecular mass	46.07 g/mol
Density	0.789 g/cm^3
Melting point	-114.3°C
Boiling point	78.4°C
Viscosity	1.20 Cp at 20°C

FEEDSTOCK CONTAINING SIMPLE SUGARS

These are feedstock that contains sugar in its basic form. In this classification is sugarcane either as stick squeezes or stick molasses. This shape is the most essential feedstock used in tropical and sub-tropical nations for creating ethanol. In European nations, beet molasses are the most used sucrose-containing feedstock. Due to the straightforward shape in which these sugars exist, it is anything but difficult to change over them to ethanol amid microbial maturation. The significant test looked by this wellspring of feedstock for ethanol generation is the opposition made by the utilization of this same feedstock as nourishment by the human populace. There are signs that proceeded with utilization of this source can influence sustenance costs over the long haul. The accessibility and cost of acquiring crude materials assume an indispensable part as far as plan of ethanol creation forms from these sorts of feedstock. Scientists have played out a point by point monetary assessment of elective procedures for ethanol creation from molasses. They watched that the cost of crude materials (molasses) represented up to 70% of the last ethanol deal cost.

COMPONENTS OF THE MACHINE

The machine has the following component units; tank, conical shape cover, electric motor, stirrer/impeller.

METHODS

Different materials were made to form a complete tank. The materials used for construction were cut, drilled and welded together were necessary.

The tank consists of the following parts.

Tank design

The steel of length 1,320 mm was cut out from the whole steel. The steel was bending on bending machine with the diameter 410 mm and 420 mm height and a round plate were cut out with a diameter of 410 mm, which was cast on the edge of height 60 mm. Gauge 2 flat bar of length 322 mm and 70 mm wide was welded to brace the edge of the tank.

Top cover

The top cover is a spherical dish shape. The stainless was formed into a spherical dish shape of diameter 410 mm by 250 mm in length and flat bar was used to brace the edge of the cover. The top plates can be either removable or welded, but it was bolted by drilling sixteen holes with a drill bit of size thirteen (13). A round pipe of 15 mm and 62 mm length was welded to the side of the cover for the discharge of the ethanol-water.

Impellers

These impellers are used to agitate the mixture together. This was constructed by a thick rod of 2.1 ft (630 mm) length and 80 mm thick was welded with flat bar of 60 mm length, 1.5 mm by 15 mm wild were arranged at an angle of 45°.

Impeller spacing

The spacing between impellers is 1.0 di to 2.0 di, where di is the diameter of the impeller. In addition, the last impeller was located 1.0 di from the bottom of the tank.

Heater

This is use to increase the temperature of the liquid/fluid in the tank. The heater has the capacity of 230 V, 50 Hz/60 Hz, 2000 W which two of it is make use of which the total capacity of the watt, voltage and frequency is doubled (460 V, 100 Hz, 4000 W) has the model number AL-0638A.

Electric/induction motor

The motor has the capacity of 230 V, 2.5 A, 1,450 RPM and has the high temperature of 60°C which was used to power the impeller to perform a circular motion for agitation/starring of the mixture.

Fermenter seat

These are constructed by using angle iron of (2 by 25 by 200) mm thickness, width and length respectively, which was cut into eight (8) pieces. Four was used for the square top and the rest for the stand for the seat. The material use in the construction of the fermenter unit was locally procured from nearby market (Agodi Gate, Ibadan) where the needed material is sold. The materials selected for the construction of the fermenter tank are listed below with the estimate **(Figure 1)**.

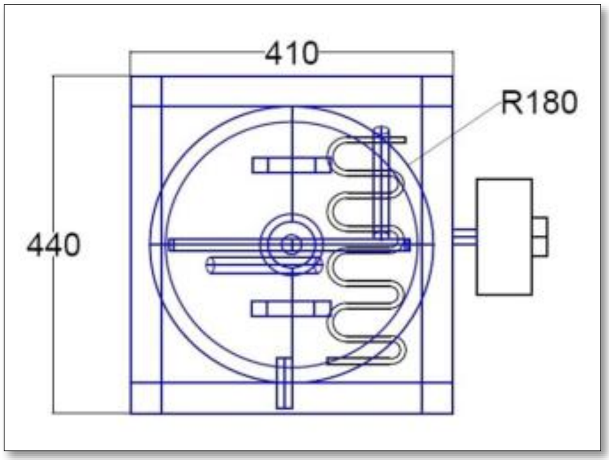

Figure 1. Isometric drawing of fermenter seat.

DESCRIPTION OF MATERIAL USED FOR THE EVALUATION

The materials used for the evaluation were 3 kg of wood shavings collected from the Mokola railway Sawmill which were divided into 3 sections each, 1200 ml (78% concentration) of tetra-oxo-sulphate (6) acid, 250 ml beakers, 1000 ml measuring cylinders, 1000 ml measuring cylinders bioreactor tank, watch, 60 l of water and electronic balance. An amount of 25 ml sulphuric acid and 10,000 l of water was used to hydrolyze 0.5 kg of wood sawdust and was allowed to sit for 2 h.

The heater was put on with the electric/induction motor for the stirrer of the mixture, 2 h. The experiment was replicated five times using different quantity (mass) of shaven wood (sawdust) and which also cause an increase in volume of acid used (1.0 kg-50 ml, 1.5 kg-75 ml), respectively, so that the average product yield would be used.

Tables 2-4 present results of ethanol production obtained for the chosen sample masses. **Table 5** presents the rate of production of ethanol obtained for all sample sizes. **Table 2 and Figure 2** shows the properties of standard ethanol compared to the ethanol produced.

Table 2. Extraction of ethanol from 1.0 kg of shaving wood (sawdust).

Replicate	Mass of wood shaving (kg)	Volume H_2SO_4 (ml)	Volume of H_2O (ml)	Mass of empty measuring cylinder (kg)	Soaking time in $H_2SO_4 + H_2O$ (h)	Mass of ethanol obtained after distilled (kg)	Volume of ethanol produced (L)
First replicate	1.0	50	20,000	1.6	2.00	0.096	0.122
Second replicate	1.0	50	20,000	1.6	2.00	0.096	0.122
Third replicate	1.0	50	20,000	1.6	2.00	0.095	0.120
Fourth replicate	1.0	50	20,000	1.6	2.00	0.095	0.120
Fifth replicate	1.0	50	20,000	1.6	2.00	0.095	0.120
Average	1.0	50	20,000	1.6	2.00	0.0954	0. 0.121

Table 3. Extraction of ethanol from 1.5 kg of shaving wood (sawdust).

Replicate	Mass of wood shaving (kg)	Volume H_2SO_4 (ml)	Volume of H_2O (ml)	Mass of empty measuring cylinder (kg)	Soaking time in $H_2SO_4 + H_2O$ (h)	Mass of ethanol obtained after distilled (kg)	Volume of ethanol produce (L)
First replicate	1.5	75	30,000	1.6	2.00	0.146	0.185
Second replicate	1.5	75	30,000	1.6	2.00	0.144	0.183
Third replicate	1.5	75	30,000	1.6	2.00	0.143	0.181
Fourth replicate	1.5	75	30,000	1.6	2.00	0.143	0.181
Fifth replicate	1.5	75	30,000	1.6	2.00	0.143	0.181
Average	1.5	75	30,000	1.6	2.00	0.1438	0.1822

Table 4. Rate of production of ethanol obtained from all samples of wood shavings.

Item	0.5 kg	1.0 kg	1.5 kg	Average
Mass of ethanol (kg)	0.0476	0.0954	0.1438	
Volume of ethanol (L)	0.0604	0.1208	0.1822	
Rate of production (L/kg wood)	0.121	0.121	0.121	0.121
Rate of production (L/tonne wood)	121	121	121	121

Table 5. Fermentation unit of ethanol plant.

Fermentation Unit of Ethanol Plant		
Part no	**Part name**	**Quantity**
1	Motor seat	1
2	Handle	1
3	Cover	1
4	Fermenter	1
5	Heater	2
6	Frame	1
7	Heater controller	2
8	Impeller	1

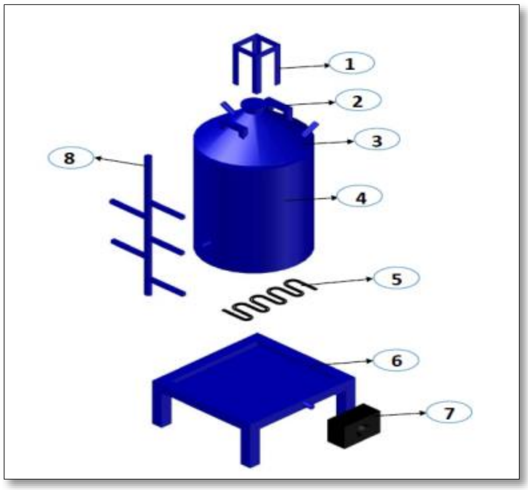

Figure 2. Fermentation unit of ethanol plant.

Equation used in calculating the mean of ethanol produces:

$$X = \frac{R1 + R2 + R3 + R4 + R5}{N} \quad (3.1)$$

X=It represents the mean of the volume of ethanol in kg

RT=R1+R2+R3+R4+R5=Sum of the replicate of the ethanol produced (kg)

N=Total number of the replicate

$$Y = \frac{X}{M} \times 100 \quad (3.2)$$

Y=Yield of ethanol extracted

X=Mean of the ethanol

M=Mass use for each experiment in producing ethanol

The two equations were used in determining the amount of ethanol produce in from Iroko timber and ethanol production from cassava **(Table 6 and Figure 3)**.

Table 6. Engineering materials cost estimate.

S/N	Description of items	Quantity	Specification	Price(₦)
1	Stainless steel	1½	8 inches by 4 inches	68,500.00
2	Electric motor	1	230 V, 2.5 A, 1450 RPM, Heat 60°C	26,000.00
3	Rod/shaft	1	80 mm	1,000.00
4	Ring coil (condenser)	1 band	Bronze	2,500.00
5	Bearing	2	Size 12	400.00
6	Heater	2	230 V, 50 Hz/60 Hz, 2000 W(each)	5,000.00
6	Cutting disc	1	Druco	900.00
7	Grinding disc	1	Druco	1,200.00
8	Stainless electrode	1 pack		1,900.00
9	Hacksaw blade	2		400.00
10	Welding machine	1	Arc welding machine	
11	Hose		2 mm of diameter by 2 ft (630 mm) in length	500.00
12	Control valve/Tap	1		250.00
13	Bolt and Nut	16 pieces	Size 13	320.00
14	Angle iron	2	1.5 mm	1300.00
15	Miscellaneous			15,200.00
Total				125,370.00

Figure 3. Plate 1: A complete fermentation unit of ethanol plant.

RESULTS

As shown in **Table 7** below, 0.5 kg of wood shavings digested using five replicates resulted in an average ethanol production of 0.0476 kg and 0.0604 L. A rate of ethanol production of 0.121 L/kg of wood was obtained from this. **Table 5** shows that a sample size of 1.0 kg of wood shavings digested using five replicates resulted in an average ethanol production of 0.095 kg and 0.1208 L. This resulted in an ethanol production rate of 0.121 L/kg of wood. As regards a sample size of 1.5 kg or wood shaven digested with five replicates, **Table 5** shows that ethanol produced was 0.1438 kg by mass having 0.1822 L by volume. This implies a production rate of 0.121 L/kg of wood. For all the samples used, an average ethanol production rate of 0.121 L/kg of wood was obtained. This figure extrapolates to 121 L of ethanol per tonne of wood. It has been noted that a tonne of fresh cassava tubers yields about 150 L of ethanol, while other scientists obtained 145 L of ethanol per tonne of cassava root.

Table 7. Extraction of ethanol from 0.5 kg of shaving wood (sawdust).

Replicate	Mass of wood shaving (kg)	Volume H_2SO_4 (ml)	Volume of H_2O (ml)	Mass of empty measuring cylinder (kg)	Soaking time in $H_2SO_4 + H_2O$ (h)	Mass of ethanol obtained after distilled (kg)	Volume of ethanol produce (L)
First replicate	0.5	25	10,000	1.6	2.00	0.051	0.065
Second replicate	0.5	25	10,000	1.6	2.00	0.051	0.065
Third replicate	0.5	25	10,000	1.6	2.00	0.046	0.058
Fourth replicate	0.5	25	10,000	1.6	2.00	0.045	0.057
Fifth replicate	0.5	25	10,000	1.6	2.00	0.045	0.057
Average	0.5	25	10,000	1.6	2.00	0.0476	0.0604

DISCUSSION

The volume of ethanol in kg produced from each sample is constant throughout the experiment. It is observed that the ethanol produced from wood shavings is at a constant of 9.5%. Scientists have presented a comparison of ethanol yield from different energy crops. It can be seen that the bio-ethanol production rate of 121 L/tonne of wood being reported in this research compares favorably with values reported for other energy crops. Grains such as maize, wheat and rice have very high ethanol conversion rates. But these are food crops that have diversified competing uses. The problem of adequate provision of food for human beings and livestock must always be solved first before their consideration for direct provision of energy. Wood shaven has no direct usage as food either for human beings and livestock. It is however a good engineering material in construction and tools manufacturing. The question of whether there will be enough wood shaven to convert to energy can only be answered by organized replanting and creation of fresh forests. Previous studies assumed an ethanol yield of 69.65 gallons (278.6 L) from yellow poplar oaks. Scientists have also stated that the ethanol yield from one tonne of woody biomass could vary from 60 to 120 gallons (240 to 480 L) depending on conversion technology and other operational conditions. Presently these assumed values are much higher than what has been obtained in this research. With further investigations, it should be possible to obtain a higher ethanol yield from wood shavings used.

CONCLUSION

The ethanol fermentation chamber has been developed and tested with wood shaven as the feedstock. The quantity of ethanol produced depends on the amount of sugar or concentrated present in the wood shavings used will lead to the amount of the ethanol to produce. The ethanol produce is very clear, pure fuel with a slight odor. The boiling point is between 70°C to 80°C.

The result obtained reveals that ethanol yield at a constant ratio of different quantity of shaving wood, shows that the result obtained are yielded at a constant rate of 9.5%.

It can be concluded that the production of ethanol from wood (sawdust) is possible locally in Nigeria, without depending on the edible ethanol sources. Furthermore, ethanol yield from wood (sawdust), even though it cannot yet replace saccharine and starchy materials, their consideration shows a possible substitute for grain based ethanol, stems from the fact that they reduce green gas emission substantially thereby changing the emission calculation.

RECOMMENDATIONS

i. As the load of petroleum product is exhausting, accentuation ought to be given to sustainable (elective) vitality sources, for example, timber squander and other rural waste. Open approach needs to support the advancement of bio-ethanol from biomass.

ii. The State and Federal governments need to take a mammoth walk toward this path. Expanded wood sawdust creation, which would require a critical responsibility of assets to arrive for generation, esterification plant, circulation and storerooms.

iii. Establishing ethanol industry in Nigeria will include a huge number of employments to the Nigerian workforce.

iv. Creating open mindfulness on reusing of agro squander items, similar to wheat straw, wood, sawdust, rice husk and so forth as a wellspring of energy will decrease natural contamination and contribute a huge number of Naira to the country's provincial economy.

v. A normal stage of communication of termers, termers dealers, expansion staff, scientists and technologist with media work force must be made.

vi. However, wood sawdust alone will not solve the problem of our dependence on fossil fuel. To overcome our excessive dependence on petroleum for liquid fuels, bans should be made on the production of food ethanol and application of the powerful tools of modern biotechnology to realize truly low costs.

REFERENCES

1. Taylor MP, Eley KL, Martin S, Tuffin M, Burton SG, et al. (2009) Thermophilic ethanologenesis: Future prospects for second generation bioethanol production. Trends Biotechnol 27: 398-405.

2. Hartman E (2008) A promising oil alternative: Algae energy. The Washington Post. Available online at https://www.washingtonpost.com/wp-dyn/content/article/2008/01/03/AR2008010303907.html

3. EUROPA (2008) Biofuels - the way forward? Environment - Science for environment policy. Accessed on: February 7, 2017. Available online at http://ec.europa.eu/environment/integration/research/newsalert/pdf/1si.pdf

4. Bamgboye AI, Oniya OO (2012) Fuel properties of loofah (*Luffa cylindrica* L.) biofuel blended with diesel. Afr J Environ Sci Technol. 6: 346-352.

5. Adelekan B (2015) ASABE 2015 paper. ASABE Annual International Meeting, New Orleans, Louisiana USA, pp: 1-8.