International Journal of Science and Healthcare Research
Vol. 8; Issue: 2; April-June 2023
Website: ijshr.com
Review Article *ISSN: 2455-7587*

A Review on Unconventional Biofuel Production from Organic Waste

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DOI: https://doi.org/10.52403/ijshr.20230230

ABSTRACT

Using biofuels, which are fuels made from organic materials that are renewable, has the potential to lessen harmful effects of fossil fuel production and use, such as conventional and greenhouse gas emissions. The production of biofuel from a variety of feedstocks and processes, in addition to well-established technologies for producing bioethanol and biodiesel, has shown high potential to provide efficient and affordable alternatives to the rapidly depleting fossil fuel supply. Examples include electrochemical carbon fixation and algal photosynthesis. By pyrolyzing appropriate biomass, a wide variety of biofuels, including charcoal, bio-oil, renewable diesel, methane, and hydrogen, can be produced.

Key words: Biogas, Green hydrogen, Biodiesel, Bioethanol.

INTRODUCTION

Generally fossil fuel was the only resource of energy in the field of transportation and in different industries due to its heating power and combustion quality. The demand is increasing gradually. All the available resources are rapidly decreasing and as a result, it will be vanished someday. Even, the development of a country can be severely impacted by an energy crisis. The resource being depleted will result in less consumption of traditional fuels in the future. The present production of fossil fuels which fails to meet the demands also aids in global warming. Ninety percent of the energy coming from fossil fuels are used in production of fuel, which emits carbon dioxide in the environment. A study also shows that the emission of carbon dioxide every year is greater than 15 million tons [1]. This demands attention towards renewable energy sources such as biomass derived fuel. Both the processes namely, physical conversion process (thermal process) and biological conversion process are utilised in converting biomass into energy [2]. The energy coming from biomass is also considered as an alternative and applied as the source of renewable energy due to its easily accessibility and cheap. The industrial
remains residue and aquatic wastes from aquatic plants are few of the various methods of biomass applied in creating energy [3], which helps in reducing the effect of bio-wastes on nature.

Biofuel production in industrialized countries is abundantly available from wide range of feed stocks which includes the waste from agriculture, municipal (MSW), domestic and industrial solid waste. Biofuels, and are put under the category of second-generation biofuels. The biofuels of second generation are generated from lignocellulosic materials (i.e. jatropha, cassava, switch grass, wood, and straw) and biomass remains, while the first-generation biofuels are obtained from edible food crops (i.e. sugarcane, wheat, barley, corn, potato, soybean, sunflower, and coconut) [4,5]

The impacts of the environment regarding disposal of wastes can be reduced by using residues of biomass and waste as prime source of biofuels, which converts the wastes which would contrarily been left to disintegrate into functional biofuels. Algae also potentially generate large quantity of lipids suitable for generation of biodiesel and are henceforth considered as raw material for third generation biofuels. This progressive biomass also can straightaway be applied in generation of widespread biofuels. Fig 1 showed the steps of biofuel production, especially the biofuels from organic waste. In this figure it is also showing the different pathways to produce Biofuels.

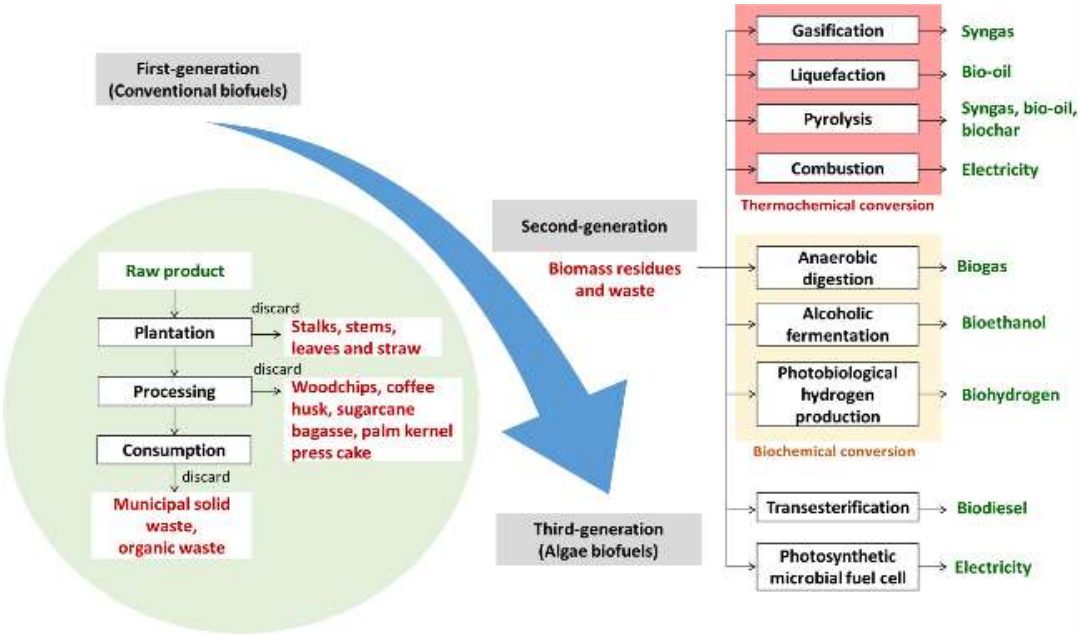

Figure 1: Steps of biofuel production, especially the biofuels from organic waste and conversion of variety of bioenergy in different pathways. Ref. 40

Sawdust, wood chips, discarded logs and other wood processing wastes can be utilized as feed stocks for biofuels [6]. Ethanol are produced by using sawdust and the wood remnants collected from different industries like saw mill, paper mills. In some research work. It was reported that in China, 72.2% of bio energy is produced from straw [7].

Food-grade virgin oils of high quality are developed via the chosen feedstock while waste oils such as *used* cooking oils are used to derive low-cost biodiesel [8, 9]. To aim for the reduction in material cost in the generation of biodiesel, waste cooking oils can be put to use in place of virgin oil as feed stocks,which shall prove efficient [10].

Due to the increasing awareness of the depletion of fossil fuel resources and environmental issues, biodiesel and bio-ethanol became more and more attractive in the recent years. The use of renewable and eco-friendly energy resources will save our nature and make it sustainable [11].

The most commonly used types of biofuels are biodiesel and bioethanol which are obtained mostly from vegetable oils, seeds and lignocelluloses. Biodiesel can act as substitute diesel and bioethanol can be utilised as petrol.

Biofuel can also be produced through the conversion of Bio methane and bio-briquette which are produced from agro industrial bio-waste and aquatic plant wastes [12]. Table 1 illustrated different methods to produce various kinds of biofuels.

Sl. No.	Procedure	Biofuel	Source
1	Transesterification	I. Bio-diesel	Triacylglycerols,
2			Calophylluminnophylum
3			Refined oil from sunflower
4	Fermentation in presence ofalcohol	II. ethanol	From algea
5			Biomass of 2 microalgaestrains
6	Combustion in absence of air	III. Methane	Sludge from sewage
7			From micro-organism

Table 1: Production of Biofuels by using different methods, Ref: 40

1.1 Biodiesel as Biofuel:

An important field of research is the generation of biofuels because of the relevance it gained due to the rise in petroleum price and its advantages on the environment. The diesel engine was invented by Dr. Rudolph Diesel and it was run by peanut oil at the Paris Exposition in the year 1900 [13]. Biodiesel is extracted from vegetable oils [14], bio butanol [15], Jatropha curcas [16] and algae [17,18]. Methanol is very common in the industries for production of bio-diesel. There were so many research works showed that the vegetable oil was a good resource of a fuel, can be used instead of diesel [19-22].In another research work, bio-diesel was produced in a reaction with soya-bean oil and methanol through trans-esterification. In this reaction acid was acts as catalyst. But the bio-diesel derived from vegetable oil is more useful as the combustion property of this bio-fuel was similar to general diesel [23].

Sometimes the mixture of bio-diesel and diesel were used in the automobiles. However it was important to analyse the properties like flash point, viscosity, density of the blended fuels before using in the automobiles.

1.2Bioethanol as Biofuel:

The raw materials containing mono saccharides from sugar cane, sugar beets were a resource of bio- ethanol. But this was first generation fuel. Hence the production of bio ethanol was produced from lingo-cellulosic substrate was more advantageous. Bio ethanol an also be produced from whey which was a solution for the disposal of this by products all over the world [24]. Lactose around 5-6%, fat around 0.06% and protein of 0.8-1% were the main constituents of whey. Kluyveromycesmarxianus, produce ethanol from lactose by fermentation reaction. K. marxianus reported that the different components of cheese can used to convert bio-ethanol [25].

Many research work showed corn and sugarcane as the main resource of ethanol. The use of ethanol blended in gasoline is very common. Ethanol also be used in bio-fuel cells and fuel cell (DEFC).

1.3Biomethane as biofuel:

Water hyacinth (WH) is an aquatic weed, which grows quickly and spreading all over the world. It causes pollution and economical loss. This weed contains high amount of nitrogenous compound [26] like ammonia, nitrite, nitrate which stimulate the growth of anaerobic- microorganism [27]. Hence biogas containing CH4 can be produced from this biomass resource [28]. The application of cassava root for starch generation (CS), on the other hand produces huge amount of waste while harvesting and manufacturing steps [29] and direct discharge of which in the environment, will cause severe impact on environment and large amount waste of lingo-cellulosic resources. The CS sediments were used for the production of bio-gas through the anaerobic reaction and also used to produce fertilizers for cassava cultivation (30). Densification is a unique process for the conversion of waste from agriculture intro briquettes which is energy rich.

In research work Photong. et al mixed the WH and CS in the ratio of 100:0, 75:25, 50:50, 25:75 and 0:100 by wet weight. The maximum yield of methane (around 436.82 mL g COD^{-1}) was achieved at pH

7.5 initially and the C/N ratio was 30 at 550C.The ratio of WH and CS were taken as 25:75. It was reported that, at the ratio of

10:90, 20:80, 30:70, 40:60 and 50:50 of WH and CS generated good fuel having calorific value similar to TCPS [31]. Total electricity of round 3.90kWh can be generated from the biological conversion of bio-methanol. On the other hand the electricity was generated around 1.42- 1.52kWh from the bio- briquettes in physical conversion method [31].

2. Biofuel from Algae

Algae can do photosynthesis reaction by chlorophyll, though it does not have roots, leaves and stem. It is either multicellular or unicellular. Micro-algae has the ability to fix CO2 ten times higher than the terrestrial plants [32]. So many research work reported that depending on the variable species, algae had fatty acids. Micro- algae grew even in very harsh environment, where low amount of nutrients were there. A good care of the sample is required for the production of bio-fuels using micro- algae. Growth of algae Chlorococcum littorale (which is CO2 tolerant algae) was observed in the presence of inorganicnitrate, carbon etc. at 295 K and 170 µmol-photon/m2/s intensity of light.

Maximum 34 wt% of fatty acid was obtained from algae with 5% CO2 concentration, which is almost similar of seed oil obtained from different land plants [33]. The lipid content and concentration of biomass were dependant on the concentration of salts, nitrate and the CO2. About 1.75g/l of bio-mass content and approximately 56% of lipid were achieved [34].

3. Bioenergy conversion techniques

To produce bioenergy, diverse variety of technologies were utilised and developed. The production of biofuel from waste was proceed through the conversion of energy from waste, can be employed to supply energy. Apart from transesterification technique, thermochemical and biochemical conversion techniques are also used in conversion of energy from organic waste.

3.1 Thermochemical conversion

High temperature chemical reformation process is involved in the conversion through thermochemical technology, where there is a requirement of bond disintegration and resolving of organic matter into biochar (solid), synthesis gas and highly oxygenated bio-oil (liquid). Three major procedural alternatives are available within thermochemical conversion, which are gasification, pyrolysis, and liquefaction. Fig 2 showed the details flowchart of gasification technology. A chemical reaction in oxygen deficiency involving heating of biomass at high temperatures (500– 1400 °C), from atmospheric pressures up to 33 bar and with low/absent oxygen content to produce combustible mixtures of gas comprises the gasification technique, where syngas was produced from carbonaceous materials in presence of suitablereagent and the catalyst. Reports also showed that this process is most suitable process for the generation of H2 gas from organic waste [35]. It has also been found that on addition of metal based catalyst, the reverse reaction is accelerated which ultimately gives the outcome of enhanced production of hydrogenand methane.

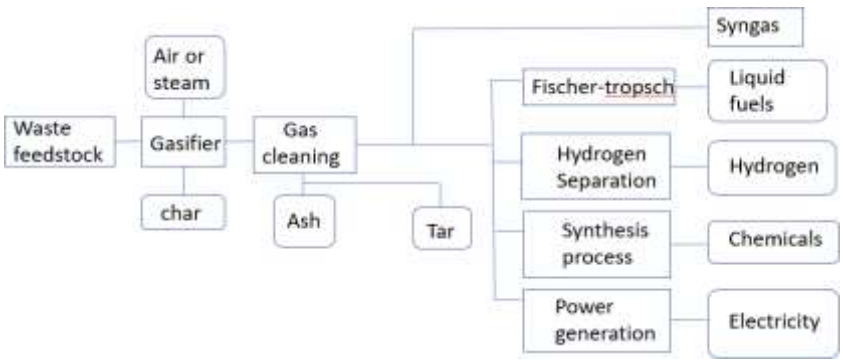

Figure 2: gasification technology, Ref. 41

The two techniques rendering products such as bio-oil or bio-crude are pyrolysis and liquefaction of biomass. The process involving the production of bio-oil at low temperature and elevated pressure with or without catalyst in the presence of hydrogen is termed as thermochemical liquefaction. An established liquefaction type that utilizing subcritical water (SCW) at medium temperatures ranging from 250 to 374 °C and operating pressure from 40 to 220 bar to convert biomass into bio-oil is known as hydrothermal liquefaction (HTL), also recognized as hydrous pyrolysis, which utilizes biomass containing high moisture which could aid in minimizing the drying or dewatering phase's expense. Therefore, biomass containing moisture in different amount like biomass from wood waste and algae- based biomass prove satisfactory for the production of bio-oil.

Pyrolysis and gasification are the two procedures under study among the thermochemical biomass conversion routes. The heat based disintegration took place within 350^0C to 550^0C and up to 700^0C temperature, is termed as pyrolysis. Under this high heat, all the organic waste converted into mixture of gases. The distinction among the two process lies in the fact that gasification generates fuel gas which can be ignited for heat generation, while, pyrolysis produces liquid fuel known as pyrolysis oil (py-oil)/bio-oil that can be an alternative for fuel oil in the application of static heating or in electricity generation. Pyrolysis procedure was more advantageous over gasification process as the produced bio fuel in liquid phase can be easily preserved and transported [36]. In Fig 3, it was shown the different types of pyrolysis process to produce biofuel.

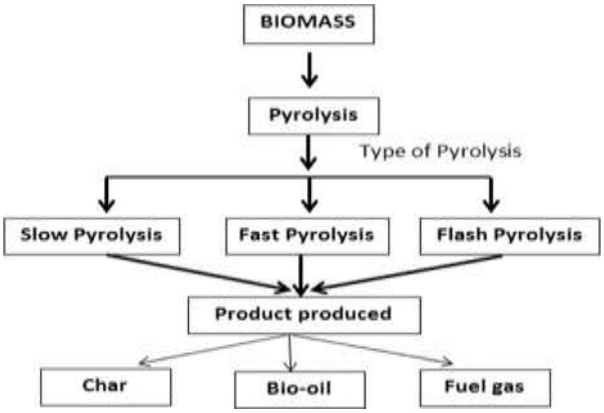

Figure 3: Different types of pyrolysis process, Ref. 41

3.2 Biochemical Transformation:

To transform biomass and wastes into productive energy, biochemical transformation utilizes bacteria or yeast. The classical process of production of biofuels includes oxidation in absence of air, fermentation in presence of alcohols and some photo biological methods..

3.3 Transesterification:

It was quite challenging to convert the oils from organic waste into organic fuels as a replacement of petrol and diesel. Several pre-treatment methods were necessary as the produced bio fuels from lignocellulose was highly viscose and poly-unsaturation was there. In transesterification process fats and oils reacted to each other to produce ester and glycerol in presence of suitable catalyst. The ester produced, was fatty acid methyl ester (FAME) which can be used instead of petrol and also glycerol has marketable worth [12].

4. Difficulties and Future aspects:

One of the most economical methods to generate renewable energy is waste utilization, which is coupled with its complementary benefit of cleaning the environment. Inevitable production of

significant amounts of biomass waste and residues from different sectors across world, can prove to be an essential resource to produce energy if economically viable and efficient technologies are brought into development. Still several drawbacks are there to produce energy from biomass and also not cheap [37]. Inadequate design and/or poor operation of MSW combustion systems for the generation of electricity could lead to the emissions of trace organics such as furans, polychlorinated dioxins, lead, mercury, and cadmium. [38]. Therefore, continuous development of a satisfactory control technology, which helps in preventing the harmful volatile emission during waste-to-bioenergy processes is necessary. Proper waste classification is as well essential for ensuring higher energy recovery efficiency in production of power and, henceforth minimizes the effects on the environment [39].

CONCLUSIONS

The use of non-renewable resources for energy production is not environment friendly and economic at all. In the near future we are going to face severe energy crisis which can prevent our social and economic growth. Hence we must focus on the use of renewable resources for the energy generation.

The problem of energy crisis worldwide can be solved by genomics. Hence now a days researchers are focussing to generate energy from renewable resources, like from bacteria, algae, bio-mass, through genomics. Thus genetic engineering may replace the fossil fuel one day. However the main obstacle is to develop bio-fuels in high scale through an efficient method is still unknown. Hence the knowledge of genomics can break down this obstacle and make the biomass more promising in the production of bio-fuels.

Declaration by Authors

Acknowledgement: None
Source of Funding: None
Conflict of Interest: The authors declare no conflict of interest.

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How to cite this article: Rakesh Namdeti. A review on unconventional biofuel production from organic waste. *International Journal of Science & Healthcare Research*. 2023; 8(2): 253-260.
DOI: *https://doi.org/10.52403/ijshr.20230230*

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