

# A Review on Production of Biofuel in backward countries Challenges and Possible solution for future biofuel production

<sup>1</sup>Aashoqullah Sajaad, <sup>2</sup>Obaidullah usefzay

<sup>1</sup>Lecturer at Alberoni University Department of Biology

<sup>2</sup>Department of Biology, Faculty of Education, Alberoni University, Kapisa, Afghanistan.

DOI: <https://doi.org/10.5281/zenodo.17454864>

Published Date: 27-October-2025

---

**Abstract:** Biofuel is produced from organic materials, juice fruit, food waste, beverage waste, corn oils and animal fats. Fuels classified as first, second, third and fourth generation, mostly first generation not require pretreatment other generation digests by chemical, physical, pyrolysis or biological pretreatments, the biological pretreatment is commercial and more economically than other pretreatments, while this pretreatment also has many challenges, require professional persons, equipment, instruments, slow – time taking process, feedstock- biomass require and many more challenge will be.

**Keywords:** Biofuel, Pretreatment, Fermentation, Pyrolysis, Bioethanol, Biodiesel, Biogas, First biofuel generation, Second biofuel generation and third biofuel generation.

---

## 1. INTRODUCTION

### 1.1 Introduction

**Definition:** The term biofuel is used in different ways. One definition is "Biofuels are bio based products, in solid, liquid, or gaseous forms. They are produced from crops or natural products, such as wood, or agricultural residues, such as molasses and bagasse. Biofuels include bioethanol from sugarcane, sugar beet or maize, and biodiesel from canola or soybeans. It goes on to define biomass in this context as "organic material excluding the material that is fossilized or embedded in geological formations" (Saadiah Hafid, 2017). Biofuel is a fuel that is produced over a short time span from feed stock, rather than by the very slow natural processes involved in the formation of fossil fuels such as oil. Biofuel can be produced from plants or from agricultural, domestic or industrial bio waste. Biofuels are mostly used for transportation, but can also be used for heating and electricity (Sofokleous et al., 2022).

In general, biofuels emits less greenhouse gas versus fossil fuels due to carbon composition of biomass that digest during pretreatments. The outcomes of lifecycle assessments (LCAs) for biofuels are highly situational and dependent on many factors including the type of feedstock, production routes, data variations, and methodological choices. This could be added to emphasize the complexity and variability in assessing the environmental impacts of biofuels. Estimates about the climate impact from biofuels vary widely based on the methodology and exact situation examined.

The two most common type's biofuel, in Brazil the largest producer bioethanol, while the EU is the largest producer of biodiesel.

Bioethanol is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as maize, sugarcane, or sweet sorghum.

Cellulosic biomass, derived from non-food sources, such as trees and grasses, is also being developed as a feed stock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form (E100) (Parisutham et al., 2014).

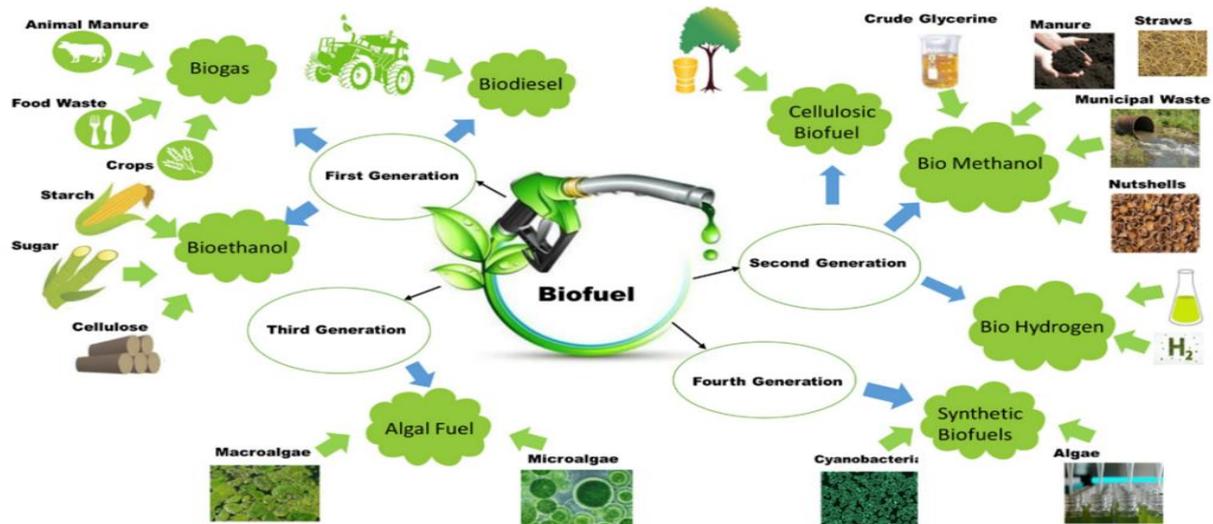


Figure 1.1: shows different fuel from different biomass

## 1.2 Types of Biofuels

### Liquid

#### *Bioethanol*

Bioethanol produced biologically from carbohydrate residue by the action of microorganisms and enzymes through the fermentation of sugars or starches (easiest to produce) or cellulose (more difficult to produce).

Bioethanol widely used in the world, produced by fermentation of sugars derived from wheat, corn, sugar beets, sugar cane, molasses and any sugar or starch from which alcoholic beverages such as whiskey, can be made (such as potato and fruit waste, etc.).

#### *Biodiesel*

Biodiesel is the most common biofuel in Europe. It is produced from oils or fats using trans-esterification and is a liquid similar in composition to fossil diesel. Chemically, it consists mostly of fatty acid methyl (or ethyl) esters.

Feed-stocks for biodiesel include animal fats, vegetable oils, soy, rapeseed, jatropha, manhua, mustard, flax, sunflower, palm oil, hemp, field pennycress, Pongamia pinnata and algae.

Pure biodiesel (B100, also known as "neat" biodiesel).

Biodiesel can be used in any diesel engine and modified equipment when mixed with mineral diesel. It can also be used in its pure form (B100) in diesel engines, but some maintenance and performance problems may occur during wintertime utilization, since the fuel becomes somewhat more viscous at lower temperatures, depending on the feedstock used (Najaf, Ghobadian et al., 2009).

#### *Green diesel*

Green diesel is produced through hydro-processing biological oil feed-stocks, such as vegetable oils and animal fats. Recently, it is produced using series of thermochemical processes such as pyrolysis and hydro-processing (Sofokleous et al., 2022).

#### *Bio gasoline*

Bio gasoline is produced biologically and thermos chemically. Using biological methods, a study led by Professor Lee Sang-yup at the Korea Advanced Institute of Science and Technology (KAIST) and published in the international science journal Nature used modified *E. coli* fed with glucose found in plants or other non-food crops to produce bio gasoline with the produced enzymes. The enzymes converted the sugar into fatty acids and then turned these into hydrocarbons that were chemically and structurally identical to those found in commercial gasoline fuel.

### ***Aviation biofuel***

Aviation biofuel (also known as bio-jet fuel) is a biofuel used for jet fuel and is a sustainable aviation fuel (SAF).

Aviation biofuel can be produced from biomass using pyrolysis, plant and animal sources such as Jatropha, algae, tallows, kitchen oils, waste oils, palm oil.

Sustainable biofuels are an alternative to electro fuels. Sustainable aviation fuel is certified as being sustainable by a third party organization (Miezah et al., 2017).

### ***Biogas***

Biogas is methane and mixture of carbon dioxide and other gases produced by the process of anaerobic condition to digest organic material by microorganisms. Other trace components of this mixture includes water vapor, hydrogen sulfide, siloxanes, hydrocarbons, ammonia, oxygen, carbon monoxide, and nitrogen. It can be produced either from biodegradable waste materials or by the use of energy crops fed into anaerobic digesters to supplement gas yields. When CO<sub>2</sub> and other impurities are removed from biogas, it is called bio methane.

### **Solid Biofuel**

#### ***Solar and Electro fuels***

This class of biofuels includes solar and electro fuels. Storage of electrical energy in the chemical bonds of liquids and gases, named as electrical energy.

A solar fuel is a synthetic chemical fuel produced from solar energy. Light is converted to chemical energy, typically by reducing protons to hydrogen, or carbon dioxide to organic compounds (M Henstra et al, 2007).

### **1.3 Generation of Biofuels**

#### ***First generation (Conventional) biofuels***

First generation biofuels (conventional biofuels) are made from fruit juice, sugar, grape, food waste, wheat flour and food crops grown on arable land, means these materials not require more pretreatment process.

The crop's sugar, starch, or oil content is converted into biodiesel or bioethanol, using trans esterification, or yeast fermentation.

#### ***Second, Third (Advanced) biofuels***

This class of biofuel noun as, second and third generation biofuels (advanced, sustainable, drop in biofuels) are made from feed-stocks which do not directly compete with food or feed crop such as waste products and energy crops. A wide range of waste feed-stocks such as those derived from agriculture and forestry activities like rice straw, rice husk, wood chips, and sawdust can be used to produce advanced biofuels through biochemical and thermochemical processes (Ingale and Gupte, 2014).

#### ***Fourth generation biofuels***

Fourth generation biofuels also include biofuels that are produced by bioengineered organisms i.e. algae and cyanobacteria. Algae and cyanobacteria will use water, carbon dioxide, and solar energy to produce biofuels. This method of biofuel production is still at the research level.

The biofuels that are secreted by the bioengineered organisms are expected to have higher photon-to-fuel conversion efficiency, compared to older generations of biofuels (Shariat Panahi et al., 2022).

### **1.4 Pretreatment**

Some materials such as fruit juice and starch, which belong to the first generation, do not need pretreatment and are converted into glucose molecules by giving less heating, converts into alcohol by yeast through the process of fermentation. Therefore, vegetable and animal oils that produced directly from seeds, crops, animal fats, as well sugars that like fruits, juices, starches, wheat flours, converts to biodiesel through pyrolysis and yeast fermentation to bioethanol. The second and third generations needs more pretreatment (Han et al., 2020).

Pretreatment is a process that the feed stock and biomass digests to small molecules like sugars, acid oils and amino acid, follow step converts to bioethanol, biodiesel and biogases. The most common pretreatments mentioned as follow:

### ***Hydrothermal Liquefaction***

Hydrothermal pretreatments is the reaction of biomass in an water containing media for the production of either liquids or, in some cases, gases. These reactions are performed relatively a high temperatures (200–600 °C) as well at high pressures (5–40 MPa) to keep the water in the liquid or supercritical phase. Reactions from 200–350 °C are typical for liquid products while temperatures above 400 °C are suitable for gaseous products. Sub and supercritical water technologies span a wide range of temperatures, feed-stocks (model compounds as well as biomass), and final products including both liquid bio-oils and gases (Sivakumar et al., 2010).

### ***Pyrolysis***

Pyrolysis is a thermochemical treatment that increases biomass energy density by removing oxygen through water and volatiles while producing oils that can be upgraded to fuel.

Pyrolysis is typically performed at temperatures of 400– 600 °C and often includes a catalyst. Biomass pyrolysis processes have been extensively reviewed.

### ***Chemical, Physical, and Thermal Pretreatments Methods***

Chemical pretreatments address the issue of biomass variability by providing a potential route for the fractionation of biomass into process streams of constituent components, like cellulosic material and lignin, as well as a way to remove ash. Specific chemical pretreatments include steam, liquid water, acids, bases, ionic liquids, sulfite pretreatment (SPORL), and ammonia fiber explosion (AFEX). Chelating agents like sodium citrate effectively remove ash from corn Stover under mild hydrothermal pretreatment. These chemical pretreatments can be strongly influenced by processing parameters. For instance, particle size and anatomical composition alter the effectiveness of AFEX for corn Stover with the larger cobs and stalks being more recalcitrant than the leaves and husk. A greater fundamental understanding of these various pretreatment technologies will enhance their use for particular conversion technologies. Densification technologies, such as briquetting and palletization, assure uniformity of physical properties, while having minimal impact on chemical composition. Densification also enables low-cost transportation, increases shelf life for outdoor storage, and improves feeding and handling performance (Sivakumar et al., 2010).

### ***Biological pretreatment***

The conversion of biomass to bioethanol depends on the hydrolysis of the carbohydrate as the ethanol-fermenting microorganisms normally are not able to directly ferment starch or cellulose to bioethanol. The hydrolysis involves the breakdown of polysaccharides into simple sugars such as glucose, which is usually catalyzed by enzymatic reaction. Particle size, moisture content, pretreatment time and temperature could affect the biomass degradation and enzymatic hydrolysis yield. Other factors such as substrate concentration, enzymes loading, pH and mixing rates also affect the rate of enzymatic hydrolysis. For carbohydrate-rich-organic waste containing high amount of starch, a mixture of  $\alpha$ -amylase can specifically catalyze the hydrolysis of  $\alpha$ -1,6-glucosidic linkages of branched polysaccharides producing a linear oligosaccharides.

Fermentable sugars such as glucose, sucrose, fructose and maltose can be produced in the saccharification process using gluco-amylase. In the hydrolysis process of the biomass containing high composition of cellulose, at least three groups of cellulolytic enzymes are involved; endoglucanase which attack low crystallinity region of cellulose fiber resulting in free chain-ends, exoglucanase that degrades and removes the cellobiose units free chain-ends and  $\beta$ -glucosidase which hydrolyze cellobiose to produce glucose.

Enzymatic hydrolysis offers more advantages over physical and/or chemical pretreatment by giving higher sugar yield than acid catalyzed hydrolysis. In addition, the enzymes are highly specific to the target substrate and can be carried out in a mild condition with temperatures ranging from 40 °C to 50 °C. Therefore, low energy is required for hydrolysis to take place with less generation of toxic compounds in the hydrolysate. However, the enzymatic hydrolysis faces the techno-economic challenges and less attractive at commercial scale due to the slow reaction rates and requires careful control of reaction conditions. Furthermore, excess cost of enzymes that may affect the overall process limits the application of enzymes as a sole pretreatment and not economically viable. As mentioned earlier, hydrolytic enzymes suffers from slow reaction rate due to the natures and recalcitrant of biomass that makes the penetration of enzymes to the active sites become difficult. This requires a pretreatments to break the structure of recalcitrant biomass to expose the starch and cellulose to enzymatic action. Therefore, the combination of pretreatment has been considered as a promising approach for sugars production with high efficiency, decreasing the formation of inhibitory and a short processing time.

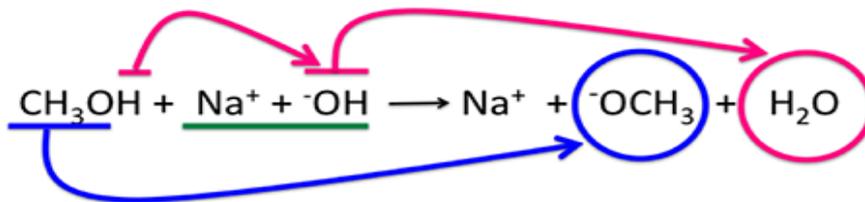
The biomass made up of from many different material and compounds, so some of pretreatments mentioned in below table, as well mostly biological method (Champagne, 2007).

## 2. METHODS FOR CONVERSION FEEDSTOCK TO BIOFUEL

I have reviewed many articles, each of which has different methods of converting feedstock into fuel, Bibra Mohit et al. mentioned in their review the separation methods, separates feedstock and waste from other wastes, pretreatment methods, Physical, chemical and biological methods, at the end, they mentioned the fermentation process and production of bioethanol. Saadiah Hafid Halimatun et, al. mentioned other pretreatment as well biological methods, they mentioned some enzymes that causes decomposition of biomass. Williams C. Luke et, al. mentioned physical, chemical, biological, pyrolysis and trans esterification methods, in the end explained the fermentation method (Bibra et al., 2023).

Trans-esterification procedure is a method, animal fats, corn oils, waste oils, vegetable oils or any other oils mixes with alcohol (mostly methyl alcohol), strong base like NaOH or KOH, is added in the medium of reaction that facilities the interaction, then the methanol reacts with fat/oil, methylation occurs.

- Methanol and base (NaOH in this case) is combined. NaOH separates into ions in methanol. The  $^-OH$  reacts with the H of methanol to make  $H_2O$ , leaving the  $^-OCH_3$  to react with the fatty acid.



- Both should be as dry as possible
- Water production increases the side reaction of soap formation, which is unwanted.

Figure 2.1 shows catalyst activity during trans-esterification

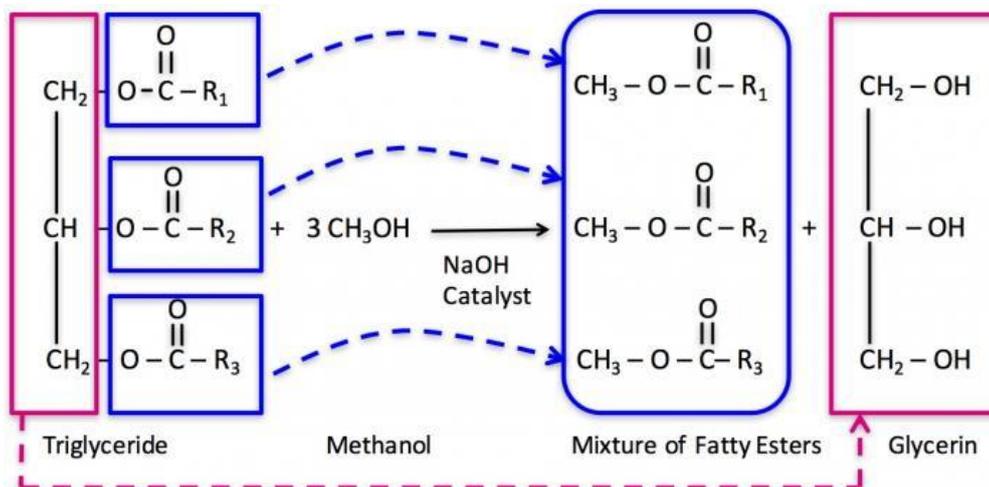


Figure 2.2: shows reaction between Triglyceride and Methanol (Trans-esterification Reaction).

Hossain Nazia et al., mentioned plant biomass, biomass composition, pretreatment as well bio reactor and bioreactor design. Bio reactor is an equipment that facilities the fermentation in large scale, in production of biofuel mostly in biological pretreatment and fermentation uses (Hossain et al., 2017).

I review many other paper as well hand book and text book in summary important methods to converts biomass to biofuel as follow:

Chemical Method: they uses some chemical compounds like acid, base or any other compounds.

Thermo-chemical methods: adds some chemical compounds as well heats.

Pyrolysis: It is a process that moistens the biomass density getting high and then adds hydrogen.

Trans-esterification: it is a process that the fats and oil esterifies by methyl groups and changes to biodiesel.

Biological Method: the main and important method, some enzyme produces by different stain of bacteria or fungi (totally microorganisms), the biomass will digest by these enzyme the simple sugar and oil produces then by fermentation procedure (bacteria or yeast) bioethanol produces (Clifford, 2023).

### **3. CHALLENGES IN BIOFUEL PRODUCTION, POSSIBLE SOLUTIONS FOR FUTURE BIOFUEL PRODUCTION**

There are many challenges in production of biofuels, so we will discuss on some important of them:

- 1- Lack of biomass in the world: the main problem is the lack of biomass, there are biomass problems everywhere in the world, because not all of the world is in a parallel economy to be able to use biomass for biofuel production. In some country biomass (specially wood and stool of caws) uses as primary fuel, in other hand the grasses that can be used as production of biofuel, used as animal feed. Food waste like, bread, oil, rice and other food waste remains in low amount in backward countries, and at the same time, these leftovers are used as food for chickens, dogs, and other domestic animals.
- 2- Equipment, instrument problem: In some country mostly poor countries do not have facilities for this purpose and cannot provide them easily, in chemical, physical, biological pretreatment and fermentation procedure so many instrument, equipment require, for biological pretreatment in primary procedure some enzyme require and these enzyme can not provide easily especially in backward country.
- 3- Lack of technical and professional people: lack of technical and professional people is one of the major problems of this goal, without these people this work is not possible and cannot be done. In some country professional persons if there is, it is little or none, or they live in difficult conditions that they cannot think about such programs.
- 4- The trucks and cars can not use bio fuel directly: some cars and some trucks can not use biofuel (bio ethanol and biodiesel) directly because of their engines, their engines have to changed, and the pumps in which the fuel is moved must be different in terms of construction, otherwise there will be problems.
- 5- People's lack of knowledge: Some countries, especially backward countries, do not have much information about the biofuel production process, and this causes people to oppose the creation and production of biofuels (Bibra et al., 2023).

#### **3.1 Possible solution for future biofuel production**

According to the survey of some researchers, crude oil may run out after some time. Therefore, one should think about its counterpart, and this counterpart can only be fuel. In some bellow point can solve the problem and challenges that mentioned above:

- 1- Training of educated people, students and training ordinary citizens of a country for this purpose.
- 2- Providing of equipment, instruments and professional persons, as same time providing of biomass, feed stock and waste for pretreatment and production of biofuel.
- 3- In cities, in order to collect the feedstock and occupied waste materials of the houses, it should be arranged with the municipality to make these materials available to the biofuel production company.
- 4- In the production of biofuel, try to use biological methods and fermentation process to a large extent, because other methods are expensive and will cost the producers in the future. The biological method is effective because microorganisms play the biggest role in the production of biofuel, the enzymes produced by these organisms cause the digestion of biomass, and then cause the next steps, which are fermentation and transesterification (Bibra et al., 2023).

### **4. CONCLUSION**

There are four generation of biofuel, first, second, third and fourth generation, the first generation is simple sugar and oil that may present in seeds, corns, animal fats, fruit juice, starch, grab juice, and so on. The second and third generation biofuel those substrates and biomass that needs pretreatment and more difficult to digest like, cellulose, wheat straw, food waste etc. The fourth generation is genetically modified algae that uses as biomass (Saadiyah Hafid, 2017).

Two type of biofuel present in generally, liquid form like; bioethanol, biodiesel, bio gasoline, aviation biofuel etc. and gas form like bio methane, bio hydrogen, bio carbon mono oxide. There is another type biofuel also and that is electro biofuel, which stores solar energy into electrical energy, and also wind energy which stores wind energy (Ingale and Gupte, 2014).

Biofuel production has many benefits, one of which is not producing greenhouse gases, because biofuel is produced from pure carbon, which is actually biomass, which is an organic compound. When biofuel is burned, it produces carbon dioxide, which is absorbed again by plants, algae, and photosynthetic bacteria, and the carbon is cycled, thus does not emits greenhouse gases and pollution not occurs, and saves the environment. Another benefit of biofuel production is that biofuel may becomes alternative of crude oil and can be used in the future.

There are some challenges for biofuel production, which include lack of professional people, lack of tools and systems, lack of awareness among the general public, lack of sufficient biomass, lack of strong communication between people and companies producing biofuel, lack of cars with biofuel engines and etc.

For this opportunity, biomass and raw materials for biofuel production should be prepared first, at the same time, many students should be trained for such a purpose, so that technical people increase, systems and tools should be prepared (Han et al., 2020).

### REFERENCES

- [1] Bibra, M., Samanta, D., Kumar Sharma, N., Singh, G., R. Johnson, G., & K. Sani, R. (2023). Food Waste to Bioethanol: Opportunities and Challenges. MDPI, 1-33.
- [2] Champagne, P. (2007). Feasibility of producing bio-ethanol from waste residues A Canadian perspective Feasibility of producing bio-ethanol from. Resources, Conservation and Recycling, 211–230.
- [3] Clifford, C. (2023, 10 7). <https://www.e-education.psu.edu/>. Retrieved from Pennsylvania State University.
- [4] Gashaw, A. (2014). Bioethanol Production from Fruit Wastes and Factors Affecting Its Fabrication. International Journal of Chemical and Natural Sciences, 132-140.
- [5] Han, W., Liu, Y., Xu, X., Huang, J., He, H., Chen, L., . . . Hou, P. (2020). Bioethanol production from waste hamburger by enzymatic. Journal of Cleaner Production.
- [6] Hossain, N., Haji Zaini, J., & Mahlia, T. (2017). A REVIEW OF BIOETHANOL PRODUCTION FROM PLANT-BASED WASTE . International Journal of Technology, 5-18.
- [7] Ingale, S., J. Joshi, S., & Gupte, A. (2014). Production of bioethanol using agricultural waste: Banana pseudo stem. Brazilian Journal of Microbiology, 45, 3, 885-892.
- [8] Konti, A., Kekos, D., & Mamma, D. (2020). Life Cycle Analysis of the Bioethanol Production from Food Waste—A Review. Energies, 2-14.
- [9] M Henstra, A., Sipma, J., Rinzema, A., & JM Stams, A. (2007). Microbiology of synthesis gas fermentation for biofuel production. Current Opinion in Biotechnology, 200–206.
- [10] Miezah, K., Obiri-Danso, K., Ka'da'r, Z., Heiske, S., Fei-Baffoe, B., Mensah, M., & Meyer, A. (2017). Municipal Solid Waste Management in a Low Income Economy Through Biogas and Bioethanol Production. Waste Biomass Valor, 115–127.
- [11] Najaf, G., Ghobadian, B., Tavakoli, T., & Yusaf, T. (2009). Potential of bioethanol production from agricultural wastes in Iran. Renewable and Sustainable Energy Review, 1418–1427.
- [12] Parisutham, V., Kim, T., & Lee, S. (2014). Feasibilities of consolidated bioprocessing microbes: From pretreatment to biofuel production. Bioresource Technology, 431–440.
- [13] Saadiah Hafid, H. (2017). Feasibility of using kitchen waste as future substrate for bioethanol. ScienceDirect, 671-686.

- [14] Shariat Panahi, H. K., Dehhaghi, M., J Guillemin, G., Gupta, V. K., & Lam, S. S. (2022). Bioethanol production from food wastes rich in. ScienceDirect, 71–81.
- [15] Sivakumar, G., R. Vail, D., Xu, J., M. Burner, D., O. Lay Jr, J., Ge, X., & J. Weathers, P. (2010). Bioethanol and biodiesel: Alternative liquid. Eng. Life Sci, 8-18.
- [16] Sofokleous, M., Christof, A., Malamis, D., Mai, S., & Barampouti, E. (2022). Bioethanol and biogas production: an alternative valorisation pathway for . ScienceDirect, 296-304.
- [17] Wang, L., Sharifzadeh, M., Templer, R., & J. Murphy, R. (2013). Bioethanol production from various waste papers: Economic feasibility. Applied Energy, 1172–1182.
- [18] Williams, C., C. Luke, T., Emerson, &, Tumuluru, J., & Li, C. ((2016)). Sources of Biomass Feedstock Variability and the Potential. Bioenerg. Res, 1–14.