Food Processing Waste to Biofuel: A Sustainable Approach

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Abstract

The present paper is reviewing utilization of FPW in generating biofuels with respect to technologies on the global perspective. The sustainable food management, substantial food wastage occur at consumer and supply chain levels in various steps of storage, packaging, transportation and delivery. Damage to crop and food products occur during natural and technological disasters. Climate change is responsible for accelerating natural disasters, that is again a trap for crop failures. Hunger, malnutrition due to unequitable distribution of resources and natural resource crisis due to population explosion are the major problems faced today. Thus role of FPW based biofuels, a step to combat climate change is introspected as an important tool towards circular bio-economy, i.e. an overall sustainable framework ensuring reduction in global greenhouse gaseous emission, reduction in poverty, economic upliftment, wasteland utilization and utilization of food processing waste.

Keywords

Food processing waste (FPW) · Biofuel · Sustainability

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20.1 Introduction

Rate of population increase is exponential putting excessive pressure on natural resources to fulfil the expanding needs of food as well as fuel, which again accelerates the cost of food production, indicating a linkage of fuel production process and food production technologies. During the process of food processing by various food technology means, there are enough generation of food processing waste (FPW) as the last by-product, which needs to addressable in waste management. Traditionally looking towards a closed ecosystem approach, there exist a sustainable food management hierarchy explaining the importance of refuse, reduce, reuse, recycle, recover, composting, vermicomposting and landfill disposal. There is a substantial increase in generation of food processing waste every year due to increase in demand of food production (Qasim and Mane 2013). Utilization of the same in production of biofuels can be a significant step in self-reliance of a country in ecofriendly food production, reducing the demand of fuels from conventional energy sources. Thus, it is a vital step towards sustainability. FPWs being rich in carbohydrates, oils, fats, proteins and organic acids can be sustainably utilized for the production of various important biofuels, biochemicals, enzymes, etc. (Girotto et al. 2015). The McKinsey consulting reports if the wastage at consumer level is curtailed by 30%, it would conserve approximately 0.100 billion acres of cropland ecosystems by 2030 (Dobbs et al. 2011). In the same way use of the food processing waste towards biofuel production reduces the pressure on cropland reducing toxic gaseous emissions due to eco-friendly combustion of biofuels.

20.2 Sustainable Framework of Food Processing Waste Based Biofuels

Accounting economic value of food processing waste, it costs approx. 310 billion dollars for the developing countries and US$ 680 billion for the industrialized countries. It has been estimated that almost 30% of the cereals; 40–50% root crops, fruits and vegetables; 20% of the oil seeds, meat and dairy products and 35% of the fish get wasted every year. 95% of the food waste is reported to be dumped at landfill sites where it gets degraded naturally releasing various greenhouse gases by anaerobic digestion, revealed in various studies (Melikoglu et al. 2013). The approx. annual cost of food processing waste is 2600 billion USD, which is equivalent to the gross domestic product (GDP) of France or the UK (FAO 2014). Waste is presently a major concern worldwide, more importantly in the developing countries (China, India, etc.) and in Europe. Wastes can be classified into industrial, sanitary, agricultural and solid urban residues based on their origin. Wastes generated by food processing companies are a good example of a pre-consumer type of waste, produced on a large scale globally (Kiran et al. 2014). Food processing and agriculture are the two vital components for the well-being of society. The production of fruits, vegetables, cattle, grains, fish, etc.; the transportation and storage of the farm products to processing plants; and the
production of food in ready-to-use forms improve and sustain the quality of human life. Potato-processing industry has the highest rate of losses. The lowest proportion of food losses is in the cereals and baking industry (21,000 tonnes) (Hegde et al. 2018).

Food losses are globally occurring with at different levels of consumption. An interesting observation is recorded that industrialized countries are encountering similar amount of food losses as in developing countries. Former facing more than 40% food loses at retail and consumer levels and latter facing the same at post-harvest and processing levels (Dar et al. 2019). The European Union contributes most of the food waste from households (47 million tonnes) and the processing sector (17 million tonnes). In Switzerland, there is almost 61% of food waste generated in the agricultural sector, 22% in the processing industry, 13% in the catering industry and 4% in the large supermarket chains.

20.2.1 Energy Context with Respect to Indian Scenario

India is an agriculture-based country. Agriculture and dairy farming produce large amount of biomass, e.g. agricultural waste (crop residues) and cow dung (gobar). The major crop residues were paddy straw, wheat straw, jowar straw, sugarcane trash, groundnut haulms, maize stalks and bajra straw, accounted for almost 88% of the total residues in the country. India processes only 2% of its produce although it being the second largest producer of cereals and fruits, third in marine production and also one of the leading countries in terms of livestock in the world. As per United Nations Development Programme, up to 40% of the food produced in India is wasted. The agriculture ministry, Govt. of India, records food loss of Rs. 50,000 crore worth every year in the country. The Indian government’s initiative of self-reliance approach should also take forward the green growth opportunities where coal reservoirs are to be exploited along with the potential of food processing waste based biofuel production technology. Research is exploring Best Practicable Environmental Option, with cheaper technologies along with social and environmental integrity.

Biomass is burnt in ‘chulhas’ in villages is an example of directly using biomass as fuel. The burning of cow dung destroys essential nutrients of soil, viz. N (Nitrogen) and P (Phosphorous). It is, therefore, more useful to convert biomass into biogas and biofuels. Methanogenic bacteria undergo anaerobic decomposition of organic waste at high temperature (38–45 °C) (thermophilic bacteria) under the ground known as digestion well or anaerobic digestor (AD). The semi-solid waste of biogas production is sludge which is highly nutrient rich and used as manure. Biogas is an eco-friendly clean fuel. Without storage tank, it can be supplied directly to the homes from plant. Pathogens and parasites cannot come in contact of faecal material as the digestion of waste takes place in closed chamber. Waste of biogas (sludge) is used as highly nutrient rich manure. It can be supplied only to few kilometres of production of biogas (Mittal et al. 2019).
20.2.2 Sustainability of Energy Plantations vs FPW Based Biofuels

Large-scale plantation of trees for production of energy from biomass is known as energy plantation. Latex of trees of the family Euphorbiaceae, e.g. *Jatropha* and *Euphorbia* species are used for energy plantations. Biodiesel is produced from the oil of *Jatropha*. Plantations on rural wastelands also provide employment to local people. Diversion of agricultural croplands to bioenergy plantations will intensify the pressure on land and forest resource which will indirectly contribute towards large releases of CO₂ in the atmosphere, also lead to increase in global food costs (Fargione et al. 2008; Searchinger et al. 2008). In a study by Spawn (2019) because of legal binding of usage of transportation ethanol in USA, usage of approximately 40% of domestic corn gets shifted to ethanol which further led to the conversion of 1.5 million hectares of grasslands into croplands releasing huge amount of CO₂, in the period of 2008 and 2012. However, utilizing FPW puts no extra pressure on agricultural land, helps in reduction of greenhouse gaseous emissions, effective management of organic waste with lots of employment opportunities. Thus, approaches of utilizing food processing waste into biofuels are the need in today’s global scenario towards sustainable food processing waste management (Zhang et al. 2013) (Fig. 20.1).

20.2.3 Food Processing Waste Based Biofuels vs Fossil Fuels

Due to high water content of food processing waste, the pathogenic microorganisms grow on it, which makes it unsuitable for conversion to biofuels. The meat industry waste with high-fat content is prone to oxidation and the spoilage due to the enzymatic actions (Fargione et al. 2008). Researchers are exploring the practically

![Fig. 20.1 Some important green growth opportunities of food processing waste based biofuels](chart)
viable ways of extraction of polysaccharides like cellulose and pectins, processing of dietary fibre, and vegetable and fruit processing wastes towards efficient production of FWP (Joonsson et al. 2013; Jitputti et al. 2006; Kim and Day 2011) (Table 20.1)

| Food processing industries | Food processing waste                                                                 | Potential characteristics of FPW utilized for biofuel production                                                                 |
|----------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Meat industry (Butchering or Slaughtering) | The liquid and solid wastes (grease, oils and fats, cooking waste, hair, feathers and the animal weight remains as by-products, from butchering or slaughtering sites) (Sahu 2016; Pap et al. 2016; Prazeres et al. 2012) | The poultry and meat processing industries generate effluents rich in both fat and proteins                                           |
| Seafood wastes             | The examples of solid by-products are heads, rejected fish, offal, skin, bones and tail (Helkar and Patil 2016) | The seafood and meat processing waste streams are rich in nitrogen. Phosphorous is added due to the use of detergents               |
| Dairy sources              | Damaged or out-dated products, solids, cheese, whey, curd and milk sludge including lactose, proteins, fats, etc. (FAO 2012) | Dairy waste is rich in dissolved protein, lactose and suspended fat                                                             |
| Fruit and vegetable processing | Stems, stalks and rotten fruits and pulp, seeds, peels and pomace                      | The wastewater of fruit and vegetable processing plants contains sugars, starches, pectin, vitamins and other components of the cell wall. They have higher BOD levels and are rich sources of many nutrients like fibres, minerals, vitamins, etc. (Mabrouk and El-Ahwany 2008) |
| Pulses and oil seed industry | A number of waste streams are generated during the processing of oil seeds. Emission in the air also takes place like grain dust, hexane solvent loss, odour during the meal drying and deodorization. The wastes from this industry are generated in the major processes like milling, extraction, deodorizing, caustic refining, acidulating, packaging, tank car washing, margarine production, bleaching winterizing, mayonnaise production and salad dressing (Tiwari et al. 2011) | The processing of legumes creates an effluent rich in proteins. Effluents from oilseed processing contain fats as suspended matter |
| Miscellaneous sources     | Wastewater from juice, soda or fruit bottling; breweries, bakeries, distilleries and sugar processing units release carbohydrate-rich effluent |                                                                                                                                 |

Table 20.1  List of food processing industries and respective waste used in biofuel production
20.3 Conventional (Non-Renewable) Energy Resources

Coal is the most abundantly found fossil fuel in the world. It contains carbon, water, sulphur and nitrogen. Coal meets 70% of the total energy needs of the world and 87.4% of all commercial energy. In India about 58% of commercial energy is obtained from coal and 38% from petroleum along with natural gas. Coal is used for cooking, heating, in industries and thermal power plants. Petroleum is useful for transportation, agricultural equipment and some industries. Natural gas is used both in cooking and in industries. Burning of coal produces SO$_2$, i.e. cause air pollution. Release of CO$_2$ and SO$_2$ gas in the atmosphere causes greenhouse effect and global warming. In thermal power plants, burning of coal also generates large amount of fly-ash. Fly-ash is a toxic waste, contains toxic heavy metals. Workers in the coal mines suffer from the following lung diseases: Black-lung disease, asthma, bronchitis, lung cancer. The gaseous fuels are basically derived from petroleum, formed due to decomposition of micro plankton deposited upon the sea beds, lakes and rivers for millions of years. The decomposition takes place by the action of bacteria, under lack of oxygen and also by catalytic cracking. It is also referred as crude oil. Liquid fuel (Petroleum) is easy to transport. Liquid fuel (Petroleum) is comparatively cleaner. Environmental impacts of petroleum include emission of toxic and greenhouse gases (NO$_2$, SO$_2$, CO, NO$_2$, CO$_2$, etc.) as combustion by-products, contamination in the water in case of the leakage. Level of awareness among general public about the adverse health impacts of environmental pollution is very low. We are hopeful that people will adapt sustainable lifestyle in the present scenario of Covid-19 pandemic (Kaushik et al. 2020). Coal and petroleum also contribute to acid rain and urban pollution. One-third of the global food production goes waste (FAO) (Lin et al. 2013). Food processing industry generates substantial high organic wastes along with high energy uses. The recovery of food processing wastes as renewable energy sources represents a sustainable option for the substitution of fossil energy, contributing to the transition of food sector towards a low-carbon economy.

FPWs are defined as residual wastes which stay after processing a primary product. Food industries release large proportions of solid and liquid wastes due to faulty processes of preparation, production and consumption of food; losses in processing steps; inappropriate transport, storage and packaging (Sahu 2016). Food processing wastes are rich in biodegradable components including vegetable and fruit waste, pits, seeds, blood, bone, process water, dairy waste, wastewater treatment sludge. They show high chemical oxygen demand (COD) and biological oxygen demand (BOD) contents. If FPWs are left untreated and unmanaged, their uncontrolled decomposition will pollute the environment due to the release of toxic materials and methane.

20.4 Innovative Management Approaches of Biofuel Production Technology

Food processing industry must be converted to an enclosed circular economy, wherein FPWs need to be used as raw materials for other industries, as a value added by-product or waste treatment substrate, integrating industrial processes
involving biochemical reactions, thermochemical reactions, biotechnology, management, business continuity.

### 20.4.1 Basic Chemistry of Biodiesel Production

Technologies converting food-waste-to-energy include biological, e.g. anaerobic digestion and fermentation, thermal and thermochemical technologies (e.g. pyrolysis, gasification, incineration, liquefaction and hydrothermal carbonization) (Schieber et al. 2001; McDougall and Hruska 2000). Thermochemical technologies reduce the amount of waste generation drastically.

**Incineration**

As per the principle of cogeneration, the heat generated by incineration of wastes can be utilized for electricity generation or could be used to operate machinery. Food wastes have lower oxygen content but higher nitrogen, ash and energy contents than wood (Digman and Kim 2008).

**Pyrolysis**

The conversion of biomass into syngas at very higher temperatures (around 1000 °C) in the absence of oxygen is known as pyrolysis. It can also be defined as the thermal decomposition of the organic matrix to produce solid, liquid and gaseous products (Canabarr et al. 2013; Balat et al. 2009).

**Gasification**

Syngas is a mixture of combustible gases, viz. carbon monoxide (CO), hydrogen (H₂), carbon dioxide (CO₂), methane (CH₄), nitrogen (N₂) and water vapours (H₂O) manufactured by burning of biomass at moderately high temperatures by the simultaneous oxidation and pyrolysis under inadequate oxygen supply (Barman et al. 2012; Brown and Brown 2003).

**Liquefaction**

Biomass is thermochemically converted into a liquid product operating at high pressure and low temperature in the presence of a catalyst. It is a costlier process because of expensive reactors. Complex fuel feeding systems also make it difficult to operate (Demirbas 2011).

**Hydrothermal Carbonization**

A process of conversion of food wastes having high moisture content (80–90%), into a valuable, energy resource under endogenous pressures and moderately low temperature (180–350 °C) is known as hydrothermal carbonization (Hoekman et al. 2011; Liu et al. 2013)
20.4.2 Biochemical/Biological Conversion Processes

The processes categorized under this category are anaerobic digestion, alcohol fermentation and biodiesel formation.

Anaerobic Digestion
This technology seems very suitable for the food processing wastes, viz. dairy waste, distillery effluent digestion (Zarkadas et al. 2015), fruit and vegetable processing wastes (Krylova et al. 2008; Noomtim and Cheirsilp 2011; Sompong et al. 2012; Scano et al. 2014), slaughterhouse wastes (Ware and Power 2016). Anaerobic digestion (AD) is a process where microorganisms break down (hydrolysis, fermentation, acetogenesis and finally methanogenesis) biodegradable materials, such as food wastes, manure and sewage sludge, in the absence of oxygen, can be carried out at both mesophilic (25–45 °C) and thermophilic (55–70 °C) temperatures, to produce biogas (Chandra et al. 2012). The semi-solid and a solid waste are the by-products of anaerobic digestion, which is used as manure and prevents soil erosion (Naik et al. 2010). Co-digestion is another process related to anaerobic digestion.

Alcohol Fermentation
Fermentation is the age-old process familiar to humans. It is used to produce foods, feeds and other well-known compounds by the utilization of microorganisms. The food processing wastes can be used to produce bioethanol and biobutanol (the liquid biofuels). These biofuels are the potential alternative sources of energy to replace petrol and diesel (conventional liquid fuels). Alcoholic fermentation producing liquid biofuels is advantageous as it can significantly reduce the greenhouse gas emissions (Macedo et al. 2008).

Biodiesel Formation
Biodiesel, which is a potential alternative biofuel to conventional fuels can be generated from food processing wastes either through chemical reaction of transesterification (by using acid or alkaline catalysts) or by microbial transesterification. Commercial generation of biodiesel is by transesterification of alcohol in the presence of a catalyst. It consists of the conversion of triglycerides (oil) to methyl esters (biodiesel) and a by-product (glycerol) (Ramadhas et al. 2005). Most of the biodiesel produced today use a base catalysis reaction (Meher et al. 2006) which provides advantages of high conversion yields at low temperatures and pressures and the minimal side reactions as well as reaction times (Baskar et al. 2019).

20.5 Biofuels from Food Processing Wastes
Mode of generation, uses and environmental impact have been discussed in Table 20.2
| Biofuel                          | Generation                                                                 | Uses                                                                 | Environmental impacts                                                                 |
|---------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| **Bioalcohols (bioethanol)**    | Action of microorganisms and enzymes through the fermentation of sugars (wheat, corn, sugar beets, sugarcane, molasses) or starches (potato and fruit waste) or carbohydrates (grain processing waste). *Saccharomyces cerevisiae* (Adaganti et al. 2014). The hydrolysis of starch to sugars (glucose) is enhanced by enzymes like α-amylase and glucoamylase. Sugar juice obtained from food wastes like fruit pomace can be directly used for ethanol production | Bioethanol is used as fuel for vehicles (USA and Brazil) | A gasoline additive to increase octane and improve vehicle emissions |
| **Biodiesel (monoalkyl esters of long chain fatty acids)** | Biodiesel is produced from animal fat, waste cooking oils, restaurant grease and vegetable oils by transesterification (Canakci 2007). Food-grade vegetable oils like soybean oil and rapeseed are popular for the production of biodiesel in the USA and Europe. The production from vegetable oils is not economically viable | Due to similarity with diesel, both are easily blended without any need for modifications | Less air pollution from diesel-powered vehicles. Pure biodiesel (B100) is the lowest emission diesel fuel (Canakci and Gerpen 1999) |
| **Green diesel or renewable diesel** | It is produced from oils of Canola, Algae, Jatropha and Salicornia by traditional fractional distillation process of oils, popularly used in Ireland | Used as fuels along with diesel | Less pollution |
| **Fuel ethers or oxygenated fuels** | When petrol is formulated with fuel ethers, they raise its oxygen content, leading to more complete | Cost-effective compounds that act as octane rating enhancers | Significantly reducing engine wear and tear and toxic exhaust emissions including level of ozone |

(continued)
Table 20.2 (continued)

| Biofuel     | Generation                                                                 | Uses                                                                 | Environmental impacts               |
|-------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------|
| Syngas      | Mixture of carbon monoxide, hydrogen and other hydrocarbons, produced by partial combustion of biomass | May be burned directly in internal combustion engines, turbines or high-temperature fuel cells | Less toxic emissions                |
| Biobutanol  | It can be easily produced from food processing wastes and cellulosic substrates with high water content. Food processing waste is reported to be better substrate for butanol production being economic, providing higher yield with less residual sugars and no dependency on hydrolytic enzymes. All the above-mentioned merits make FPWs potential feedstocks for n-butanol production at commercial scale (Huang 2015) | Unlike ethanol, it can be blended with gasoline (Huang et al. 2015) |                                                                                  |
| Biogas      | Anaerobic digestion is recommended for biogas (methane) production from food processing wastes (Chandra et al. 2012). Complex food processing wastes consisting of animal fats, protein and lignocellulosic biomass are to be undergone hydrolysis to form simpler units (sugars, fatty acids, amino acids). Afterwards converted to volatile fatty acids which are | Heat or electricity generation                                        |                                                                                  |
Biodiesel is an eco-friendly alternative of fossil fuel and its production from food processing waste is one of the sustainable options depending upon availability of economically viable technology. Combustion of biodiesel generates less air pollutants as compared to fossil fuels. Biodiesel synthesis is a transesterification reaction of lipids (present in animal fats and vegetable oils) in the presence of alcohol, base, acid, enzyme or solid catalyst. (Sarkar et al. 2020)

Waste eggshell was found as highly active and reusable catalyst in triglyceride transesterification reaction making it economically viable and environmental friendly option to reuse the eggshell waste (Wei et al. 2009). Another study to optimize biodiesel production from the waste oil of pork grilling process in the food factory in Udon Thani, Thailand used it as a raw material. KOH was reported as an

| Biofuel   | Generation                                                                 | Uses                                                                 | Environmental impacts                                                                 |
|-----------|---------------------------------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Biohydrogen | later converted to acetate, to be acted upon by methanogenic bacteria to produce methane (Chandra et al. 2012) | The high calorific value, easy availability and environment-friendly nature make biohydrogen a prospective biofuel (Sangyoka et al. 2016) | It releases clean by-product after combustion (Kotay and Das 2008)                     |

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effective catalyst in the transesterification reaction (Singhasiri and Tantemsapya 2016). Biodiesel production is also successfully reported from *Stauntonia chinensis* seed oil waste. It showed an ideal fatty acid composition. SC biodiesel was found with better fuel properties as compared to various feedstock oils (Wang et al. 2014).

### 20.6 Biodiesel Production from Various Food Processing Wastes

Food-grade vegetable oils are inexpensive raw material for biodiesel production but still prove to be more expensive than diesel fuel. In a study to analyse the free fatty acids and moisture in the waste material, it was found that former content varies from 0.7% to 41.8% and latter varies from 0.01% to 55.38%, reducing the efficiency of transesterification in converting these feedstocks into biodiesel. (Canakci and Gerpen 1999)

An integrated approach of co-digestion of sewage sludge (SS) and food waste (FW) is analysed in a study in China. The results showed that a biggest synergistic effect happened in the co-digestion of SS and FW in volatile solid (VS) mixing ratio of 1:1 with the highest methane yield of 415.3 mL/g VS (Wang et al. 2000).

### Genetic Engineering Strategies

Use of genetic engineering strategies to produce biodiesel from yeast, plant and algae is one of the latest approaches. The oil content of the plant can be increased by genetically modifying the lipid biosynthetic pathway. It has been observed that an increase in the activity of acetyl-CoA carboxylase increases the lipid synthesis by enhancing the utilization of malonyl-CoA in the biosynthetic pathway. Also, changing the composition of the fatty acid of plant seed oil improves the biodiesel production. In an attempt to enhance the biodiesel production from *Arabidopsis*, it was observed that overexpression of WRINKLED1 (WRI1) mRNA is directly associated with the increase in seed oil. WRI1 regulates the seed storage metabolism and its expression under the CMV 35S promoter increases the seed oil content and also accumulates triacylglycerols in developing seedlings.

Various metabolic engineering methods have been used for constructing lactose-consuming *Saccharomyces cerevisiae* strains, using the lactose genes of the yeast *Kluyveromyces lactis*, *Escherichia coli* and *Aspergillus niger*.

### Hybrid Processes for Improving Biofuels Production

In the past few years, studies have been carried out to produce hydrogen by integrating dark fermentation process (first stage) and photo fermentative process (second stage). The volatile fatty acids (major deterrent for the hydrogen production) formed in the first stage of the fermentation can be used as a substrate in the second stage. A two-stage process for improved hydrogen production was developed where glucoamylase was first used to hydrolyze the food waste. The hydrolysate was then further utilized as a substrate for batch fermentation and continuous fermentation.
processes. The highest cumulative production of hydrogen was observed with a yield of 245.7 mL H\textsubscript{2}/g glucose in the batch system (Tenca et al. 2011).

Similarly, studies have been carried out to produce hydrogen and methane from food waste in a two-stage anaerobic digester. Both the fermentations were carried out in continuously stirred tank fermentors and the effect of continuous circulation on the efficiency and stability of processes was also investigated. Maximum H\textsubscript{2} production achieved was 3 L hydrogen per litre per day and maximum methane was 2.9 L methane per litre per day and about 70% degradation of volatile fatty acids was also observed (Silva et al. 2018).

The suitable materials for biohydrogen production should be rich in carbohydrate but be nitrogen deficient. Among the various substrates assessed, food processing wastes being comparatively cheaper and have been an ideal biodegradable organic matter for biohydrogen production through dark fermentation (FOEN 2018). The type of cultures whether pure, co-culture or mixed also influences the biohydrogen yield. Giannis studied the H\textsubscript{2} production from various types of cheese under different pH values (6.5–7.5) and reported the highest yield of 170 ml H\textsubscript{2}/kg of total organic content (TOC).

20.7 Conclusion

Food processing wastes are produced at an alarming rate. The management of these wastes is of utmost importance. Biofuel production from these wastes is the most feasible option as it helps in alleviating the dependence on conventional fuels and also reduces greenhouse emissions. The various approaches of biofuel production (like anaerobic digestion, alcoholic fermentation and thermochemical conversion methods) from FPWs are promising and well-consolidated methods. There is still the need to explore and research the various aspects of valorization of FPWs, the dissemination of knowledge to common masses regarding the efficient utilization of food processing wastes. Traditional knowledge with respect to utilization of food processing waste as biofuels should also be given priority over technological options because that can be the quickest, low-resource demanding innovative method. Technological inputs to such traditional innovations can be worth magical solutions. The government and industries should join hands to give research wings from laboratories to commercial scale.

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