Renewable and Sustainable Energy Reviews 53 (2016) 945–953

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Liquid biofuels from food waste: Current trends, prospect and limitation

Sanjib Kumar Karmee [1]

School of Energy and Environment, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong

ARTICLE INFO

Article history:
Received 16 February 2015
Received in revised form
25 May 2015
Accepted 18 September 2015
Available online 10 November 2015

Keywords:
Food waste
Biodiesel
Bioethanol
Biooil
Sustainable fuel

ABSTRACT

Depletion of fossil fuels, environmental damage due to pollution and energy security have intensified research on alternative liquid biofuels. A major portion of municipal solid waste is food waste. Huge quantities of food waste is generated worldwide and currently its disposal is becoming a challenge. Food waste contain carbohydrates, lipids, phosphates, vitamins and amino acids. Carbohydrate, lipid and carbon containing materials present in food waste can be converted to bioethanol, biodiesel and biooil. Lipid extracted from food waste is converted to biodiesel in 95–97% yield. On the other hand, 92–96% bioethanol obtained by fermentation of food waste. Along this line, pyrolysis of food waste can be performed to obtain biooil and biochar. In this paper, technical feasibility, prospects and policies for liquid biofuel preparation from food waste was evaluated. Also, limitations of using food waste as a resource for biofuel production is discussed.

Contents

1. Introduction

Researchers are investigating new and alternative liquid biofuels for various reasons such as (i) depletion of fossil fuels, (ii) increasing demand for liquid fuels, (iii) energy security and less dependency on politically unstable middle east countries and (iv) environmental pollution [1]. In this regard, biofuels are becoming

E-mail address: sanjibkarmee@gmail.com
[1] Present address: School of Chemical and Minerals Engineering, North-West University, Potchefstroom Campus, Private Bag X6001, Potchefstroom, 2520, South Africa.

http://dx.doi.org/10.1016/j.rser.2015.09.041
1364-0321/

increasingly important as alternative energy source. Different biofuels such as bioethanol and biodiesel are used as substitute to diesel fuel and gasoline in many countries [2–10]. Furthermore, bioethanol and biodiesel can be used as blend along with gasoline and petro–diesel. According to reports by Food and Agricultural Organization of the United Nations approximately 1.3 billion tons of food waste is discarded globally without any further use [11]. These food wastes almost account to one third of the worldwide food produced for the human consumption. Food waste generated in developing Asian countries is expected to rise further in the upcoming years because of rapid economic expansion and continuous population growth. For instance, from 2005 to 2025 food waste produced in the urban stettlements of the Asian economies is all set to rise from 278 to 416 million tons [12]. Along this line, worldwide 1300 million tonnes of food waste is generated; whereas, Asia and South-eastern Asia produces 278 and 79.3 million tonnes of food waste [11,12]. Asian economic giant China alone produces 82.8 million tonnes of food waste [13]. Fig. 1. shows the present data on food waste generation in Asia-Pacific countries [14].

In most of the countries generated food waste is disposed at landfills along with municipal solid wastes. For instance, in Hong Kong in 2012, around 9278 t per day of municipal solid waste was disposed in landfills [15,16]. Out of this total municipal waste, around 36–40% was food waste or biobased waste [15,16]. Food waste is considered as the largest category of municipal solid waste that is disposed in landfills. This is causing world's mounting food waste disposal problem which is further encouraged by throwaway culture. This practice of disposing food waste in landfills is creating many problems in public life such as bad odor, air pollution, and leaching. Landfills are known to generate carbon dioxide, methane and other toxic gaseous substances [15,16]. Specifically, methane is the most abundant greenhouse gas generated from landfills. Rainfall event results in leaching of undesirable leachate which pose risk to public health. In addition, landfills also occupy a lot of space which is further a constraint for metropolitan cities where land is costly and needed for infrastructure development. To circumvent these problems recyling of food waste is necessary.

To a large extent, development of sustainable food waste valorization is needed to solve the waste disposal and environmental problems. At present, many conventional food waste valorization methods exists to recycle food wastes such as incineration, anaerobic digestion, and processing it as fish and animal feed purposes [15,16]. Nevertheless, conversion of food waste to potential liquid biofuels is important; and it is currently being investigated by many researchers as they can be used as fuels in pure form or as blend in existing diesel engines [17–20].

Presently, biofuels are produced from edible feedstocks. Feedstocks contribute significantly (around 80–90%) towards the total

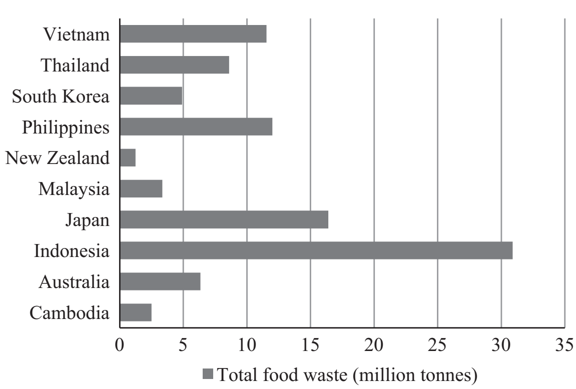

Fig.1. Food waste produced in Asian and Asia-Pacific countries [14].

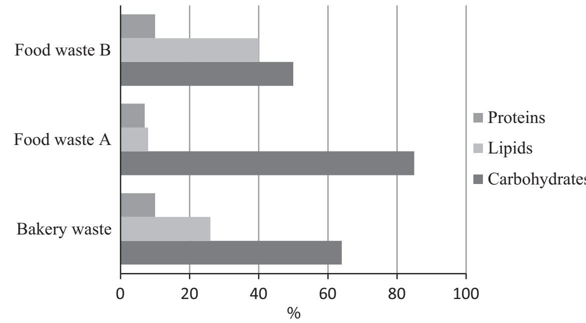

Fig.2. Amount of protein, lipid, and carbohydrate present in bakery waste. Sample A and B are mixed food waste obtained from same canteen in different days [38,39].

cost of biofuels [21]. Thus, use of edible feedstocks make biofuels costly. Alternatively, non-edible feedstocks are extensively investigated for biofuel production in academia and industry [22–28]. There is also a growing food vs fuel debate among the concerned mermbers of the civil societies and stake holders [29–31]. Many critics are also arguing that increased in land use for growing biofuel crops will result in shortage of land, water and other resources for growing food crops which will contribute towards food shortage [29–31]. However, biofuels can be produced in alternative ways by using wastes as non-edible resources. In this regard, waste cooking oil and food wastes can be utilized to produce biofuels without using land availabile for growing food crops [32–34]. Further, recycling food wastes for biofuel production will also avoid the ongoing food vs fuel debate.

Food waste mainly composed of (1) rotten fruits and vegetables, (2) fish and poultry organs, intestine, meat trimmings and other residues, (3) fruits and vegetable peelings, (4) meat, fish, shellfish shells, bones, (5) food fats, sauces, condiments, (6) soup pulp, herbal medicinal pulp, (7) egg shells, cheeses, ice cream, yogurts, (8) tea leaves, teabags, coffee grounds, (9) bread, cakes, biscuits, desserts, jam (10) cereals of all types e.g. rice, noodles, oats, (11) plate scrapings and leftover of cooked food, (12) BBQ raw or cooked leftovers, and (13) different pet foods [15,16]. Food waste is considered a zero value resource since it is discarded without any use. Chemically, food wastes contain lipid, carbohydrate, amino acid, phosphate, vitamins and other carbon containg substances (Fig. 2) [18–20]. Lipid derived from food wastes can be conveted to biodiesel [18–19]. Additionally, complex carbohydrate such as cellulose and starch in food wastes can be hydrolyzed into small sugars viz. glucose and fructose. Subsequently, these sugars can be fermented to bioethanol [18–20]. There are also reports about pyrolysis of the food waste into biooil [35–37]. Liu et al. have reviewed biotechnological production of ethanol, methane and hydrogen from food waste [14]. Whereas, Pham et al. reviewed the use of different technologies such as biological (viz. anaerobic digestion and fermentation), thermal and thermochemical (viz. incineration, pyrolysis, gasification and hydrothermal oxidation) for conversion of food waste to energy. In this review, technical aspects of the preparation of liquid biofuels from food waste is discussed. Industrial viability of selected processes are evaluated. In addition, policies, prospects and limitations of using food waste as a no-value resource for biofuel production is described.

2. Production of liquid biofuels from food waste

Food waste disposal is increasingly becoming challenging. Most of these food wastes are dumped directly in landfills everyday. Biochemical decomposition of food waste results in unpleasant smell and formation of unhealthy degraded products [15,16]. To circumvent this problem, several countries have formulated future