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Biodiesel produced from waste animal fat has a good impact in reducing environmental pollution-A review

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Abstract:

Biodiesel is produced from vegetable oils, yellow grease, used cooking oils, or animal fats. The fuel is produced by transesterification—a process that converts fats and oils into biodiesel and glycerine (a coproduct). Global warming and fossil fuel depletion have boosted the search of alternative and renewable fuels with low environmental impact. Biodiesel exhibits many advantages over conventional diesel including the possibility of being produced from renewable sources such as waste oils and fats. Especially waste animal fats are receiving increased attention as an alternative to vegetable oils for biodiesel production. The fats had been proven to a viable feedstock when compared to vegetable oil and waste cooking oil in terms of productivity and economy.

Key words: Biodiesel, waste animal fats, Chicken fat, animal slaughter houses

Introduction:

The human society, with its expansion and high technological development, is very dependent on petroleum fuel for its activities. However, fossil fuels are non-renewable resources, which take millions of years to form with limited reserves and high prices. The production and use of fossil fuel in engines with internal combustion cause environmental problems such as rising carbon dioxide levels in the atmosphere, increasing the average ambient temperature of the Earth. In consequence, a global movement toward the renewable energy sources is one way to help to meet the increased energy needs of humanity. In the group of alternate and ecologically acceptable substitutes for the conventional fuels, biodiesel has attracted an increased attention worldwide.

Animal byproduct production, as part of the meat and poultry processing chain, is huge. For instance, it represents nearly 17 million tons per year only in the European Union [1]. Most of the waste results from over 328 million pigs, sheep, beef, goats and dairy cattle and 6 billion chickens, turkeys and other poultry that are slaughtered every year in Europe [2]. After rendering, materials classified as edible which amount up to 12 million tons, are processed in a variety of food and feed related sectors [3]. The remaining byproducts that are considered inedible have other applications for disposal such as biofuels and biodiesel for energy generation [4,5]. It is energy generation, especially biodiesel production, that is one of the most attractive and expanding applications [6]. In this sense, the production of biodiesel guarantees a better profitability of inedible animal byproducts. Animal waste also consists of the organic matter resulting from the meat processing industry as well as from human consumption. Biodiesel consists of mono-alkyl esters of long chain fatty acids produced from oil or fat, but the use of vegetable oil adds a high price to biodiesel, and this has prompted the use of animal fats as an interesting alternative. In addition to its renewability, biodiesel also constitutes an attractive alternative because it offers better lubricating properties than fossil diesel fuel and it is biodegradable and non-toxic. It also has an improved cetane number and high flash point [7]. Biodiesel also contributes to sustainability by reducing the carbon footprint due to lower CO_2 emission compared to fossil diesel fuel [8].

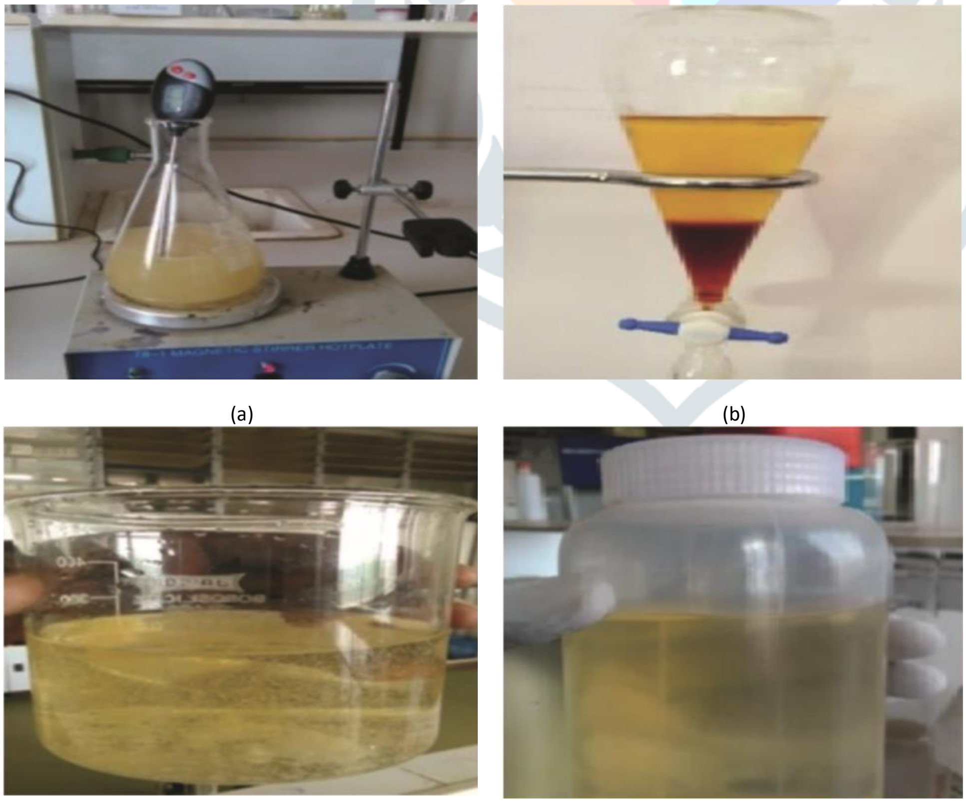
Biodiesel can be used in existing diesel engines without the need for substantial modification. Biodiesel has a higher oxygen content than conventional diesel and the carbon to hydrogen ratio is also lower. This explains the major advantages of biodiesel such as lower emission of particulate matter, but also a lesser content of sulfur, hydrocarbon and carbon monoxide [9-10]. The major challenge nowadays is the production of environmentally and economically viable biodiesel [11] and the use of animal fat waste could contribute towards achieving this goal. This review is highlighting the latest advances in the available processes for biodiesel production from animal fat waste.

Numerous researches have been cried out on biodiesel production from plant seed oil whereas limited researches have been performed on transesterification of animal fat for biodiesel production. Initial work on animal fat was based on trans esterifying waste fleshing oil and evaluating its performance on a diesel engine [12]. As the viability of the biodiesel turned out to be feasible, the physiochemical properties for a mutton waste fat biodiesel were analysed along with its emission and combustion characteristics [13]. The study moved ahead towards understanding the composition of biodiesel by trans esterifying duck tallow with potassium hydroxide as catalyst, which explained that the end result obtained was oleate, a trans esterified product of oleic acid [14]. In addition to meat processing wastes, fleshing wastes from leather industries have proved to be an alternative source of fat for biodiesel production, which can be blended to ordinary diesel for combustion-based application [15-16]. These wastes are discarded into environment because of its zero usability.

Animal Fats as Feedstock About 328 million animals (cattle, sheep, pigs and goats) and 6 billion poultry (mainly chickens and turkeys) were slaughtered in 2014 in the European Union. Such a high number of slaughtered animals produces enormous amounts of waste animal residue including fats that need to be treated to reduce pollution or recycled to give them some added value [17-18]. Such fats include beef tallow extracted from rendering fatty tissue of cattle, mutton tallow from rendering sheep, pork lard from rendering pigs and chicken fat from rendering feathers, blood, skin, o al and trims [19-20]. The wet rendering process includes the presence of water and fats heated below 49 C. The goal is separation of the fat from the protein fraction. Other fats are those resulting from meat and the meat processing industry and those from recycling of the industrial cooking business. Such recycled greases that are produced from heated animal fats collected from commercial and industrial cooking can be classified as yellow grease and brown grease depending on the content of free fatty acids (FFA). Yellow grease is considered if FFA < 15% by weight and brown grease when FFA > 15% [21].

(a) (b)

Figure1: (a) Dry animal fat collected; (b) fat oil generated from WAF



(c) (d)

Figure2: (a) Crude biodiesel obtained; (b) glycerol separation; (c) filtered biodiesel; (d) biodiesel after distillation

CHEMISTRY OF ANIMAL FAT

The fat primarily consists of (i) Triglycerides, (ii) Phospholipids and (iii) Sterols. The triglyceride molecule compromises of three fatty acids molecules connected with a common glyceride spine having substantial amount of oxygen infused in its structure [22] and these fatty acids reacts with alcohol during transesterification reaction to produce Fatty Acid Alkyl Ester (biodiesel). The difference between fat and oil is based upon the saturation and its degree in the carbon chain. Oil exists in liquid phase because of unsaturated fatty acids (monounsaturated, polyunsaturated) whereas animal fats like suet, tallow and lard exist in solid state because of saturated fatty acids. The variation in fatty acids is based upon the number of carbons in the chain, degree and number of saturations in it [23]. The phospholipids can be removed by degumming the fats using orthophosphoric acid (in case of acid degumming) or with water (in case of water degumming). Vegetable oils have high unsaturated fatty acid (mainly oleic and linoleic acid) content whereas animal fat has good amount of fatty acids with saturation (Palmitic and stearic). Most commonly used waste animal fats for biodiesel production are pork lard [24], lamb meat, beef tallow, chicken fat and animal fat mix [25]. The recycled greases consist of monoglycerides (MG), diglycerides (DG), triglycerides (TG) and varying amount of FFA (8-40%) depending upon its source.

How Animal Fats are Processed

Waste fat from animal carcasses are removed and then made into an oil using a rendering process. Rendering consists of grinding the animal by-products to a fine consistency and cooking them until the liquid fat separates and pathogens are destroyed. The solids are usually passed through a screw press to complete the removal of the fat from the solid residue. The cooking process also removes water, which makes the fat and solid material stable against rancidity. The end products are fat, and a high-protein feed additive known as “meat and bone meal.”

Figure 3:Beef tallow.

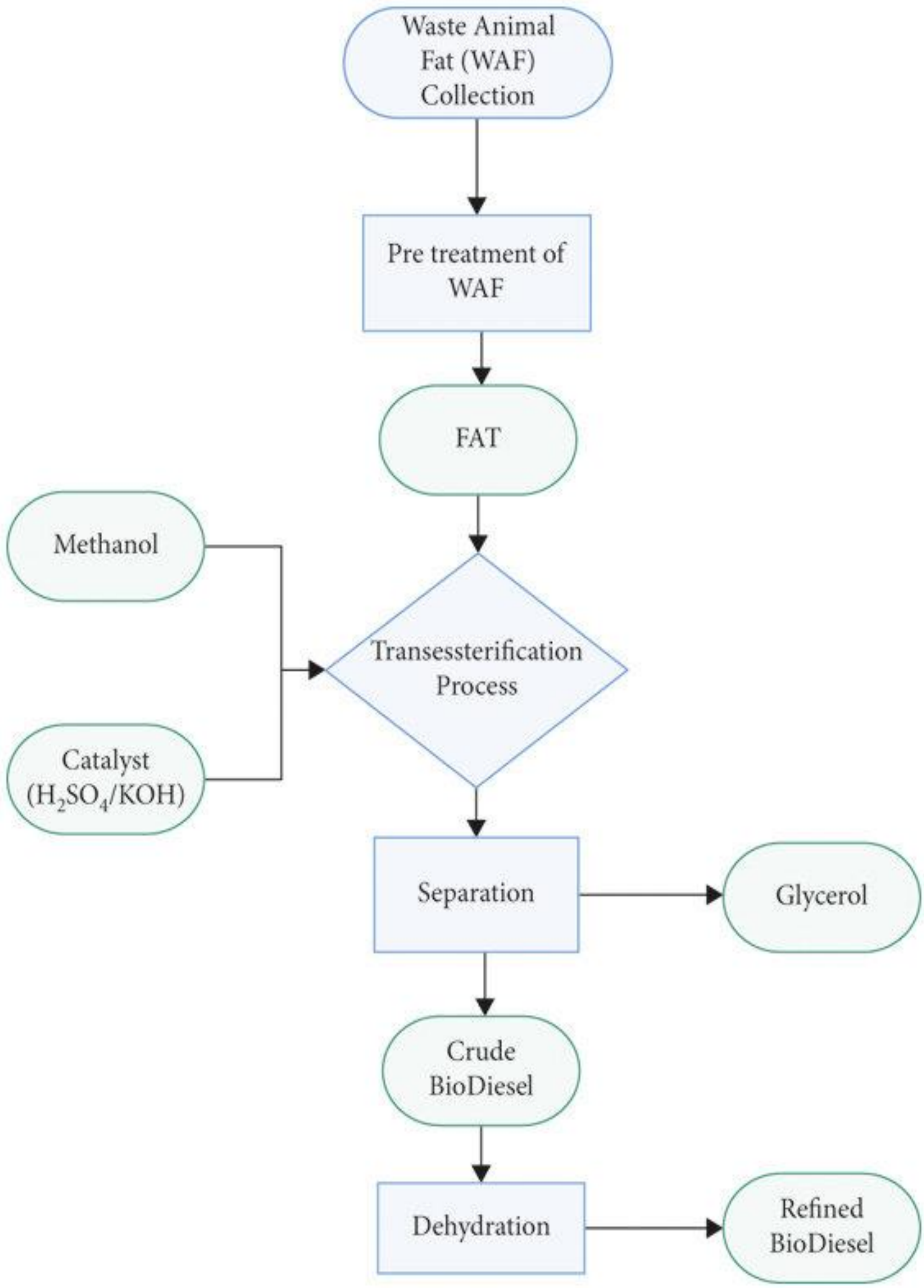


Figure 4: Schematic diagram of the biodiesel production methodology.

Conclusions:

Biodiesel produced from agricultural waste has been rapidly expanded around the world due to its relevant advantages such as being biodegradable, renewable and sulphur-free. The cost of biodiesel majorly depends on the cost of the raw materials being used, with animal fat waste being cheaper than vegetable oil waste. Animal fats, usually found as waste from slaughterhouses, the meat processing industry, and cooking facilities, can be used as feedstock for biodiesel production. As reported in this manuscript, there are numerous processes already available for the production of biodiesel from animal fats and operating conditions during transesterification.

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