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Review

Feasibility of edible oil vs. non-edible oil vs. waste edible oil as biodiesel feedstock

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ABSTRACT

Biodiesel has high potential as a new and renewable energy source in the future, as a substitution fuel for petroleum-derived diesel and can be used in existing diesel engine without modification. Currently, more than 95% of the world biodiesel is produced from edible oil which is easily available on large scale from the agricultural industry. However, continuous and large-scale production of biodiesel from edible oil without proper planning may cause negative impact to the world, such as depletion of food supply leading to economic imbalance. A possible solution to overcome this problem is to use non-edible oil or waste edible oil (WEO). In this context, the next question that comes in mind would be if the use of non-edible oil overcomes the short-comings of using edible oil. Apart from that, if WEO were to be used, is it sufficient to meet the demand of biodiesel. All these issues will be addressed in this paper by discussing the advantages and disadvantages of using edible oil vs. non-edible vs. WEO as feedstock for biodiesel production. The discussion will cover various aspects ranging from oil composition, oil yield, economics, cultivation requirements, land availability and also the resources availability. Finally, a proposed solution will be presented.

Contents

1. Introduction

In the past few decades, fossil fuels mainly petroleum, natural gas and coal have been playing an important role as the major energy resources worldwide. However, these energy resources are non-renewable and are projected to be exhausted in the near future. The situation has worsened with the escalating energy consumption worldwide due to rapid population growth and economic development. This has caused the price of crude petroleum to hit a record high of USD (US dollar) 90 per barrel in October 2007 and still rising. Therefore, there is an urgent need to find a new energy resource that is renewable, clean, reliable

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and yet economically feasible as a substitution to the current fossil fuels. In this context, recently, biodiesel derived from vegetable oil has been shown to be a potential alternative replacing petroleum-derived diesel oil for diesel engine.

Biodiesel is mono alkyl ester derived from oils (plant or animal) which have characteristics similar to petroleum-derived diesel oil. Currently, about 84% the world biodiesel production is met by rapeseed oil. The remaining portion is from sunflower oil (13%), palm oil (1%) and soybean oil and others (2%) [1]. Since more than 95% of the biodiesel is made from edible oil, there are many claims that a lot of problems may arise. By converting edible oils into biodiesel, food resources are actually being converted into automotive fuels. It is believed that large-scale production of biodiesel from edible oils may bring global imbalance to the food supply and demand market. Recently, environmentalists have started to debate on the negative impact of biodiesel production from edible oil on our planet especially deforestation and destruction of ecosystem [2]. They claimed that the expansion of oil crop plantations for biodiesel production on a large scale has caused deforestation in countries such as Malaysia, Indonesia and Brazil since more and more forest has been cleared for plantation purposes. Furthermore, the line between food and fuel economies is blurred as both of the fields are competing for the same oil resources. In other words, biodiesel is competing limited land availability with food industry for plantation of oil crop. Arable land that would otherwise have been used to grow food would instead be used to grow fuel [3]. In fact, this trend is already being observed in certain part of this world. There has been significant expansion in the plantation of oil crops for biodiesel in the past few years in order to fulfill the continuous increasing demand of biodiesel. Fig. 1 shows the trend in global vegetable oil ending stocks due to the production of biodiesel in the years 1991–2005 [4]. Although there is continuous increase in the production of vegetable oil; however, the ending stocks of vegetable oils are continuously decreasing due to increasing production of biodiesel. Eventually, with the implementation of biodiesel as a substitute fuel for petroleum-derived diesel oil, this may lead to the depletion of edible-oil supply worldwide.

In order to overcome this devastating phenomenon, suggestions and research have been made/conducted to produce biodiesel by using alternative or greener oil resources such as non-edible oils. In fact in India, nearly half a dozen states have set aside a total of 1.72 million hectares of land for jatropha cultivation and small quantities of jatropha biodiesel are already being sold to the public sector oil companies. In this context, the next question that comes in mind would be if the use of non-edible oil overcomes the short-comings of using edible oil. Or rather it just simply diverts the issue and not solving it completely as plantations for non-edible oils still requires large plantation land areas. Alternatively, can waste edible oil (WEO) be used instead, and is it sufficient to meet the demand of biodiesel. All these issues will be addressed in this paper by discussing the advantages and disadvantages of using edible oil vs. non-edible vs. WEO as feedstock for biodiesel production. The discussion will cover various aspects ranging from oil composition, oil yield, economics, cultivation requirements, land availability and also the resources availability. The non-edible oils that were included in this study are jatropha, rubber seed, castor (*Ricinus communis* L.), sea mango (*Cerbera odollam* or *Cerbera manghas*), and *Pongamia pinnata* (abbreviated hereafter as *P. pinnata*). Finally, at the end of this paper, authors' point of view to overcome this issue will be presented.

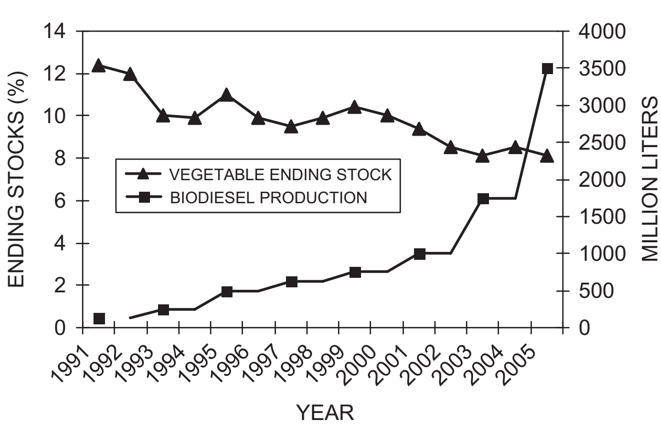

Fig. 1. Global vegetable oil ending stock and biodiesel production.

2. Characteristic of edible and non-edible oil

2.1. Oil yield

The oil yield from the crops itself is always the key factor to decide the suitability of a feedstock for biodiesel production. Oil crops with higher oil yield are more preferable in the biodiesel industry because it can reduce the production cost. Generally the cost of raw materials accounts about 70–80% of the total production cost of biodiesel. Table 1 shows the oil yield in terms of kg/ha and wt% and also the price for various types of edible and non-edible oils in the world. It is clear that higher oil yield always corresponds with lower cost. Some of the costs of the non-edible oils cannot be obtained as they are currently not traded in the open market.

From Table 1 we can see that palm oil was found to give the highest oil yield with 5000 kg oil per hectare; this value is far higher than other oils which are only in the range of hundreds to 2000 kg oil per hectare. On the other hand, among the various non-edible oils shown in Table 1, jatropha was found to give the highest yield. This is followed by *P. pinnata* and castor. However, the oil yield in *P. pinnata* is not stable, depending on many factors such as plantation and oil extraction technique of the oil crops.

2.2. Oil composition

Another important criteria to determine the suitability of oil as a raw material for the production of biodiesel is the composition of the oil itself. The composition of oil will subsequently determine the properties of the biodiesel obtained. The effect of oil composition on the properties of the biodiesel produced will

Table 1
Oil yield for major non-edible and edible oil sources

Type of oil	Oil yield (kg oil/ha)	Oil yield (wt%)	Prices (USD/ton)
Non-edible oil			
Jatropha [5,6]	1590	Seed: 35–40, kernel: 50–60	N/A
Rubber seed [7]	80–120	40–50	N/A
Castor [5,9]	1188	53	N/A
Pongamia pinnata [8]	225–2250	30–40	N/A
Sea mango [9]	N/A	54	N/A
Edible oil			
Soybean [5,11]	375	20	684
Palm [5,12]	5000	20	478
Rapeseed [5,13]	1000	37–50	683