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PRODUCTION AND CHARACTERIZATION OF BIODIESEL FROM CHICKEN FEATHER

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ABSTRACT
From waste to energy generation is considered as potential approach to resolve the challenges associated with waste management and energy crisis. Currently waste to energy contributes about 114.08 MW of power capacity, which is far less in compare to other renewable sources. The present article reports the experimental work on the comparative evaluation of two bio-feeds *i.e*. waste chicken feather and Ghee (Clarified butter) for biodiesel production. Parameters such as percentage yield, specific gravity, acid value, saponification value, peroxide value, melting point were evaluated for biodiesel obtained from both biofeeds *i.e*. Chicken feather and Clarified butter. Present study revealed that oil obtained from CF contained higher acid value (8.64 meq/g), saponification value (110.78), peroxide value (7.89 meq/kg) and melting point (37°C) than the Clarified butter. Similarly, free fatty acid such as Oleic acid, Lauric acid, Ricinoleic acid, Palmitic acid was also found higher in CF than CF. Significant reduction in acid value, peroxide value, melting point was observed in methyl ester obtained from selected bio-feeds. Free fatty acid composition of CF based methyl ester showed close value as obtained in commercial biodiesel; on the other hand present study suggested that CF could be a potential biodiesel feedstock if impurities and saponification number reduced during processing.

KEYWORDS: Waste to energy; bio-feed; biodiesel; methyl ester; acid value.

INTRODUCTION

Energy is required as a necessary input to secure the reasonable standard of living and technological advancement. Energy consumption has been increased enormously due to increased developmental activities, transportation, urbanization and other miscellaneous sector. Presently, coal, oil and natural gas, are playing lead role to meet this energy demand in the world. The huge consumption of fossil fuel has increased the level of pollution, which is a serious global concern (World energy Outlook, 2016). The global oil consumption has increased by 1.9% per day which is nearly double of the recent historical average (1%) (BP, 2016). Oil is dominated over other primary energy resources as it contributes about 32.9% in global energy consumption (BP, 2016). Among developed countries, Japan is producing 75% of total primary energy supply (TPES) by the fossil fuel based power plants, 90% in South Korea and similar production in Taiwan also (Southeast Asia Energy Outlook, 2013). Similarly India also depends on fossil fuel energy sources to full fill its 80% primary energy demand (IEA, 2014). It has been proven that fossil fuel is unsustainable and poses serious environmental threats such as climate change which leads to the series of adverse impacts like heavy flood, loss of biodiversity, rise in earth temperature, rise in sea level *etc*. (Wang *et al*., 2017). Thus, significant growth in energy demand and rise in pollution level calls for the implication of non polluting renewable energy sources such as solar, wind, biomass and waste to energy generation (Sikarwar *et al*., 2017). Biomass based renewable energy generation comprises carbon, oxygen, hydrogen and partial concentration of nitrogen. Biomass based energy generation have advantage over the other renewable energy sources due to its low dependence on site and climate. On the other hand biomass can be easily stored and transported (Sikarwar *et al*., 2017). Biodiesel is an ecofriendly and alternate non fossil fuel derived fuel that consist of alkyl esters of plant oils and animal fat. ASTM defined biodiesel as a fuel composed of mono alkyl esters of long chain fatty acids derived from renewable vegetable oils or animal fats" (Srivastava and Prasad, 2000). There are various methods of biodiesel production are used such as pyrolysis, blending, microemulsions and transesterification (Amber *et al*., 2014). In all these, transesterification is most commonly used method for biodiesel production from plant and animal fat. The common waste material used for biodiesel production are jatropha, soyabean, coconut, sunflower, groundnut, palm, olive oil, chicken fat, waste cooking oil and rapeseed. In this context, chicken feather is considered as a potential biomass for biodiesel production (Kondamudi *et al*., 2009). Chicken feather meal is being used as animal feed due to its protein content and it has been also used as fertilizer due to high N content. Chicken feather is poultry waste and constitute higher percentage of protein, nitrogen and animal fat. It is cheap in nature and reduces animal waste disposal cost. It has been found that the fat content of feather varies from 2 to 12% which depends on the type of feather used. For instance chicken feather contains approximately 11% fat while duck feather contains 6.7% fat (Dale, 1992). The present study is an attempt to evaluate the qualitative potential of chicken feather to be used for biodiesel production in compare to the home made ghee and market available ghee.

MATERIALS & METHODS

Collection of raw material and oil extraction

Chicken feather was collected from local poultry farm. About 150g of feathers were weighed by analytical balance and chopped well using knife and scissors. The round bottom flask filled with 900ml of hexane and placed in heating mantle. Energy level of mantle was set to 40 until hexane starts boiling, at which point, the energy level was set to a minimum. Apparatus allowed operating for 8 hours and finally mixture of hexane was separated into its constituents by rotator evaporation. Equipment run until all the hexane is separated.

Physico-chemical parametric analysis

Oil obtained from chicken feather, homemade ghee and market available ghee was analyzed for its qualitative evaluation. Following parameters were evaluated by following the standard procedures:

Moisture content

A 5 ml of beaker was weighted using analytical balance. 1 ml of oil was drawn in beaker by pipette and subsequently weighted. The whole content kept for 1 hour at 50 ºC, which was further kept at room temperature in desiccators for 15 minutes to achieve constant weight. These steps were repeated till the achievement of three concordant values. Moisture content (%) was calculated by observing the difference in weight of beaker.

Specific gravity

Specific gravity is the density of substance and water at particular temperature. Substances with specific gravity >1 are denser than water and thus sink in it while the substances with specific gravity <1 are less dense than water and thus float in it. Specific gravity is a special case of Relative Density. Specific gravity is mathematically expressed as: P_1 / P_2

Where P_1 is the density of the substance and P_2 is the density of water.

An empty pycnometer weighed using analytical balance.1 ml of distilled water was pipetted in it and subsequently weighed using analytical balance .The pycnometer then dried.1ml of oil poured in it and weighed.

Acid value

Acid value (or "neutralization number" or "acid number" or "acidity") is the mass of potassium hydroxide (KOH) in milligrams that is required to neutralize the free fatty acid present in one gram of chemical substance. The acid number is a measure of the amount of carboxylic acid groups in a chemical compound. In a typical procedure, a known amount of sample dissolved in organic solvent is titrated with a solution of potassium hydroxide with known concentration and with phenolphthalein as a color indicator. The acid number is used to quantify the amount of acid present in the sample. It is the quantity of base, expressed in milligrams of potassium hydroxide that is required to neutralize the acidic constituents in 1 g of sample. Acid value of the selected substrates were analyzed by following the titration method comprising phenopthelin indicator, 0.1 N KOH and 1 g of oil. Following formula was used to calculate the acid value (mg/g oil):

$$\text{Acid Value (A.V.)} = \frac{\text{56.1 X Titer Value X Normality}}{\text{Weight of Sample taken}}$$

Peroxide value

Lipid oxidation measurement can be obtained by peroxide value. The mainly oxidative rancidity test is used for determination of peroxide value in fat or oil. Peroxides are intermediates in the autoxidation reaction.

About 5g of oil was taken in conical flask and 30 ml solution of chloroform: acetic acid in ratio 2:3 and 0.5 ml of saturated KI solution were added to it. This mixture was then allowed to stand for 1 min. 30 ml of distilled water was added to mixture and finally titrated with 0.01N sodium thiosulphate with vigorous shaking until yellow color disappeared .This was followed by addition of a 0.5 ml 1 percent starch solution with vigorous shaking to release all the iodine from the chloroform layer until brownish blue color disappears. Blank was also titrated in same way. The peroxide value was calculated by following equation:

$$\textbf{Peroxide Value} = \frac{\text{(Sample – Blank) X Normality of KOH X 1000}}{\text{Weight Of the sample taken}}$$

Solubility of oil

About 200ul of methanol, ethyl acetate and hexane pipetted into different eppendorfs which was further added with oil. The whole content was then vigorously shaken on a vortex mixer. 5 ml of oil was poured in to 3 beakers and kept at 4-10 ºC for approximately 1 hour till the oil gets solidified. Oil was then removed outside from the freeze and its melting point was recorded.

Insolubility of oil

In order to determine the insolubility of oil, approximate 10g of oil was taken in the beaker and kept in hot air oven for 1 hour to remove the moisture content. Then 50 ml of kerosene was added in oil sample to dissolve the impurity and the whole content was kept on hot plate. The impurity was measured by placing the filter paper containing impurities over a pre-weighted crucible.

Transestrification

Selected oil samples were converted in to biodiesel by following the base catalyzed transesterification process. In this process methanol (CH_3OH) and sodium hydroxide (NaOH) was used as a alcohol and catalyst respectively in a molar ratio of 6:1 as prescribed by Alptekin and Canakci, 2010. The amount of catalyst was 1% of the weight of the initial amount of fat in the chicken fat+ the neutralization amount as calculated by Van-Gerpen *et al*. (2002-2004).

RESULTS & DISCUSSION

Characteristics of oil obtained from selected bio-feeds

Applications of animal fats for biodiesel production are being used by various researchers and it is considered as low cost substrate for biodiesel production (Kirubakaram and Selvan, 2018).The present study provides comparative characteristics of Chicken feather, Ghar ghee and Market Ghee for their efficiency of biodiesel production. About 11.85% of oil content was obtained from chicken feather based feedstock which is in line with the oil content reported by Kondamudi *et al.* (2009). From Table 1 it is depicted that moisture content (%) was highest in oil obtained from CF in compare to the home made ghee and market available ghee. Similarly specific gravity and acid value was also found highest in oil of CF. The value of other parameters such as specific gravity, Acid value peroxide value, unsaponifible matter were found maximum than that of obtained with Clustered Butter (CB). On the other hand the characteristics fatty acids required for biodiesel production was found highest in CF than that of CB. Acid value provides the estimation of Free Fatty Acids (FFA) present in oil samples. Higher the FFA content lowers the conversion efficiency of oil in to biodiesel. Estimation of free fatty acids revealed that CF contained higher percentage of Oleic, Lauric, Ricinoleic, Palmitic acid than the CB (Table 2). Adewale *et al.* (2015) also observed the fatty acid composition in waste chicken fat and found about 8.4% Palmitic and 42.5% Oleic acid. In another study about 4.42% Palmitic and 60.92% Oleic acid is reported (Jagadale and Jugulkar, 2012).

Characteristics of biodiesel obtained from CF and CB

From the Table 3 and 4 comparative properties of biodiesel obtained from Chicken feather and Clustered Butter can be observed. Clustered Butter showed the higher yield (90%) biodiesel than Chicken feather (80%). Parameters such as acid value, peroxide value melting point were reduced after the transesterification of oil of both biofeed. Acid value and peroxide value for CF based biodiesel was 0.82 mew/kg and 5.49 meq/kg respectively while for CB based biodiesel it was about 0.55 meq/kg and 1.16meq/kg respectively. Saponification number was found higher in both biodiesel in compare to the saponification number of their respective oils (CF and CB). Fatty acid such as Oleic, Lauric, Ricinoleic and Palmitic acid was found higher in CF based biodiesel than CB derived biodiesel. On comparison with commercial biodiesel properties CF based biodiesel was found more suitable than the CB derived biodiesel.

The important parameter that affects the yield of methyl ester is methanol to oil ratio (v/v) during the transesterification step. In present study methanol to oil ratio was kept constant for both biofeed, though higher yield is obtained with clustered butter. It is due to lower acid value of CB. Most researchers suggest that higher amount of alcohol is required to drive the reaction close to completion; higher molar ratio results in to greater ester production in shorter time (Demirbas, 2009).

Specific gravity (SG) represents the ratio of weight of experimental solution with distilled water, the SG of CF and CB was reduced when converted in to biodiesel, thus the obtained final product was lighter than their feedstock. ASTM standard for specific gravity of biodiesel is 0.858. Biodiesel obtained from CF and CB was found within the range of standard limit.

TABLE 1. Parameters for qualitative analysis of oil (is:548(part 1)-1964)

Parameters tested	Ob. Value for c.fat	Ob. Value for ghar ghee
Oil yield	11.85%	-----
Moisture content	0.26%	0.24%
Specific gravity	0.86%	0.83%
Acid value	8.64 meq/g	0.55 meq/g
Saponification value	110.78	82.17
Peroxide value	7.89 meq /kg	2.37meq/kg
Insoluble impurities	35.45%	16.78%
Unsaponifable matter	0.09%	0.01%
Melting point	37° C	30° C

TABLE 2: Fatty acid composition in selected oil samples

Free fatty acid-	*CF	*CB
a) Oleic acid	4.3465%	0.1403%
b) Lauric acid	3.0826%	0.099%
c) Ricinoleic acid	4.5931%	0.1463%
d) Palmitic acid	3.9594%	0.1274%
Solubility-		
a) Hexane	soluble	soluble
b) Methanol	insoluble	insoluble
c) Ethyl acetate	soluble	soluble
Reichert Meissile	2.59%	1.29%

*CF = Chicken Feather; *CB= Clustered Butter

TABLE 3: Properties of biodiesel obtained from selected oil samples

Parameters Tested For Biodiesel	Ob. Value For C. Fat Biodiesel	Ob. Value For clustered butter Biodiesel	Ob. Value For Commercial Diesel
% Yield	80%	90%	------
Moisture content	0.24%	0.12%	0.05%
Specific gravity	0.78%	0.78%	0.58%
Acid value	0.82 meq/g	0.55 meq/g	1.09 meq/g
Peroxide value	5.49 meq/kg	1.16 meq/kg	1.59 meq/kg
Saponification value	134.50mg/g	72.39mg/g	30.68mg/g
Insoluble impurities	28.29%	12.49%	20%
Melting point	18° C	17° C	37° C
Unsaponifable matter	0.04%	0.003%	0.07%

TABLE 4: Free Fatty acid composition and of biodiesel obtained from selected oil samples

Free fatty acid-	Ob. Value For C. Fat Biodiesel	Ob. Value For Ghar Ghee Biodiesel	Ob. Value For Commercial Diesel
a) Oleic acid	0.4136%	0.1081%	0.3036%
b)) Lauric acid	0.2933%	0.0599%	0.1956%
c)) Ricinoleic acid	0.4371%	0.1165%	0.3371%
d)) Palmitic acid	0.3755%	0.0847%	0.1845%
Solubility-			
a) Hexane	soluble	soluble	soluble
b) Methanol	soluble	soluble	soluble
c) Ethyl acetate	soluble	soluble	soluble
Reichert Meissile	0.66%	2.38%	1.64%

CONCLUSION

Biodiesel has been proven as potential alternative for fossil fuels and offers various advantages over the conventional fuels. Biodiesel is considered as renewable source of energy as it can be derived from plant as well as animal biomass. earlier studies have shown that plant based biodiesel production involve irrigation cost, fertilizer cost and cost of cultivation which adds higher processing cost in final biodiesel production. In contrast to this present study has proven a cost effective and sustainable way of biodiesel production. It can be concluded that Chicken Feather has enormous potential for being used as feedstock for biodiesel production. However there is still pretreatment step is required to enhance the yield of biodiesel.

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