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Development and quantification of biodiesel production from chicken feather meal as a cost-effective feedstock by using green technology

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ABSTRACT

Increased urbanization and increase in population has led to an increased demand for fuels. The result is the prices of fuels are reaching new heights every day. Using low-cost feedstocks such as rendered animal fats in biodiesel production will reduce biodiesel expenditures. One of the low-cost feedstocks for biodiesel production from poultry feathers. This paper describes a new and environmentally friendly process for developing biodiesel production technology from feather waste produced in poultry industry. Transesterification is one of the well-known processes by which fats and oils are converted into biodiesel. The reaction often makes use of acid/base catalyst. If the material possesses high free fatty acid then acid catalyst gives better results. The data resulted from gas chromatography (GC) revealed these percentages for fatty acid compositions: myristic acid, palmitic acid, stearic acid, oleic acid, linoleic acid and arachidonic acid. The biodiesel function group was analyzed by using FTIR. This study concluded that the rooster feathers have superior potential to process them into biodiesel than broiler chicken feathers fat because of fatty acid composition values and it has important properties of biodiesel.

1. Introduction

Energy is the single most important resource capable of sustaining life on earth. Energy not only is the engine of economic growth but also the cause of important life threatening outcomes [4]. The strong interest in liquid biofuel is due to the fact that it can be used as a supplement, or alternative, to gasoline or diesel fuel derived from petroleum fossil fuel [1,7]. Over time with entrance of oil as new and cheap fuel, tendency to this fuel increased. Biodiesel, a replacement of petroleum diesel, derived from biological sources received increasing attention globally as it lessens the dependence on petroleum products, the energy crisis and environmental pollution [6]. Biodiesel is a non petroleum-based alternative diesel fuel that consists of alkyl esters derived from renewable feedstocks such as plant oils or animal fats. A successful biofuel industry will not be based on digestible starch from staple crops such as corn. The main problem the biodiesel industry frequently faces is the availability of cheap and abundant, high-quality feedstock. Thus, finding alternative, nonfood, feedstocks such as waste vegetable oil, grease, and animal fats (beef tallow) is considered a necessity for the industry. Through continued research to produce biofuels from nonfood sources, it has been discovered that poultry feather offers another promising feedstock source for biodiesel production [4,5,11]. Feather fat is a low-cost feedstock for biodiesel production compared to high-grade vegetable oils [3,9]. Feathers are byproducts of poultry processing plant and produced in large amount. Worldwide 24 billion chickens are killed annually and around 8.5 billion tones of poultry feather are produced. Currently the poultry feathers are treated in some ways such as dumping, landfilling, composting and incinerating, which involve problems in storage, handling, emissions control and ash disposal [2,10]. Moreover feather meal is used as an animal feed, given its high protein content, and also as a fertilizer because of its high nitrogen content [11]. The utilization of feather fats for biodiesel production is a good alternative to recycle these wastes [8]. The transesterification method is commonly used for biodiesel production because of its higher yield and lower energy consumption. Transesterification is a chemical process of reacting triglycerides with alcohol in the presence of a catalyst. If the reaction is not completed, then there will be mono-, di- and tri-glycerides left in the reaction mixture. Alcohols such as methanol,

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ethanol or butanol can be used in the transesterification [12,13] It generally involves a three step reversible reaction in which initial triglycerides yields a mixture of fatty acid methyl ester (FAME) and glycerol in the presence of three catalysts: acid, alkali and enzyme. The present study is designed to emphasize on processing and characterization of biodiesel from poultry waste (i.e. chicken's feather meal) by the process of transesterification and then characterized its fuel properties according to standard test methods.

2. Materials and methods

2.1. Sample collection

The chicken and rooster waste feather samples were collected from SD poultry farm (Gollamadugu, Chittoor District, Latitude-13.213386°N, Longitude 79.094836°E), Sample was collected in a sterile plastic bags and it was brought to the laboratory for further processing. The collected sample was washed with sterile distilled water and air dried under the room temperature. The dried feathers were stored in refrigerator for further use.

2.2. Extraction of fat from feather

About Twenty grams of feather sample was taken and stirred it continuously with 200 mL of 5% NaOH at 90 °C for 45 min on hot plate. The feather completely dissolved and absorbed fat melted and floated on the surface of layer. The dissolved feathers were transfer to plate and cooled at room temperature. The plates were transfer to hot air oven for 1 h and evaporate the excess of Water. The dried feather meal was collected and stored at 4 °C for further use [25].

2.3. Extraction of Lipid

The total lipid content was extracted by Bligh & Dyer extraction method [23]. In a 100 mL conical flask containing 5 g or 5 mL of sample, 20 mL methanol and 10 mL chloroform were added and the mixture was vortexed for 2 min 10 mL of chloroform was added and the mixture was shaked vigorously for 2 min 18 mL of distilled water was added and the mixture was vortexed again for 2 min. The chloroform layer was separated by centrifugation at 2000 rpm for 10 min. The lower layer was transferred to a pear-shaped flask with a Pasteur pipette. Second extraction was made with 20 mL 10% (v/v) methanol in chloroform by vortexing for 2 min. After centrifugation, the chloroform phase was added to the first extract. Evaporation was done with rotary vapor and the residue was further dried at 104 °C for 1 h [26].

2.4. Biofuel extraction

The feather oil content was extracted from feather meal samples using a modified Folch and Lee's method. Dried feather meal (10 g) were taken and added with 20 mL of chloroform/ methanol (2:1 v/v) at 25 °C after cell disruption in a 25 W sonicator (Branson model 2510) and incubated. Tubes were incubated for 10 min at room temperature to allow the organic and aqueous layers to separate. After removing and saving the bottom (organic) layer, the aqueous layer was re-extracted by adding chloroform (6–8 mL), to separate the layer. The resulting extracts (6–10 mL each) were stored at 4 °C prior to removing aliquots for oil analysis. Fatty acid composition analysis was performed using gas chromatography (GC) method.

2.5. Biodiesel separation: (transesterfication method)

Base catalyzed transesterification method was carried out in a 250 mL glass beaker equipped with a magnetic stirrer. Feather meal lipid (100 mL) was taken in flask and potassium hydroxide (1.8 g) dissolved in 33.5 mL methanol was added to flask. Stirring was continued for 2 h at 55 °C, the mixture was transferred to a separatory funnel and glycerol was allowed to separate for a minimum of 3 h. After draining off the glycerol, methyl ester was washed twice with 1:1 vol of water for 1 h to remove excess methanol [21,22].

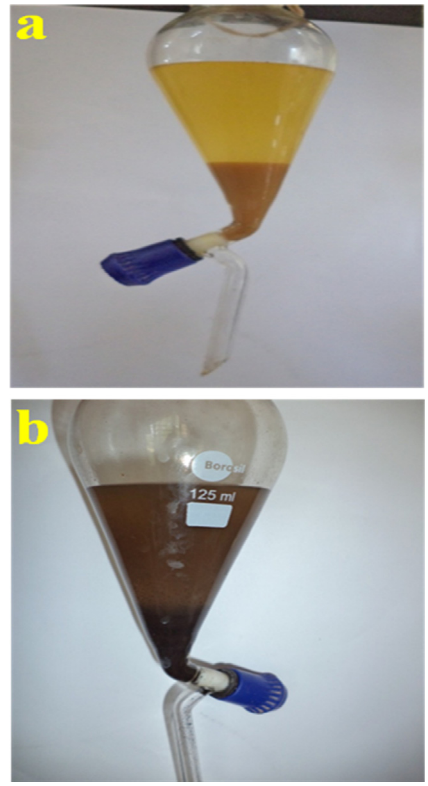

Fig. 1. Transesterification process (a. Chicken and b. Rooster).

Table 1
FTIR analysis of biodiesel for rooster and chicken.

Characteristic absorptions (cm^{-1})		Functional group	Type of vibration
Rooster	Chicken		
3700–4500	–	Amide	N-H Stretch
3550–3200	–	Phenols & Alcohols	Hydrogen-bonded O-H Stretch
3100–3010	–	Alkynes	=C-H Stretch
3000–2500	3000–2500	Carboxylic Acids	Hydrogen-bonded O-H Stretch
2950–2850	–	Alkenes	C=C-H Asymmetric Stretch
2600–2800	–	Alkynyl	C=C Stretch
2300–2500	–	Carbonyl	C=O Stretch
2000–2200	–	Ketones	C-C=C Symmetric Stretch
1300–1500	1300–1500	Aromatic	C=C Bending Stretch
900–1200	900–1200	Aromatic	C-O Stretch
860–680	860–680	Aromatic	C-H Bending Stretch
850–550	850–550	Stretch	C–Cl alkyl halides

2.6. FTIR (Fourier Transform Infra Red Spectroscopy) analysis of lipid

The FTIR were recorded in the mid-IR region 4000–400 cm^{-1} at room resolution 4 cm^{-1} with scans using Thermo Nicolet FTIR Nexus spectrometer coupled with TGS (Tri-glycine sulphate) detector. The interferometer and the detector chamber were purged with dry nitrogen to remove spectral interference due to atmospheric carbon dioxide and water vapor. Air background spectrum was recorded before each sample and all experiments were performed in six triplicates (six pellets