# Production and Characterization of Biodiesel from Fatty Residues of *Capra hircus*

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## ABSTRACT

**Background:** Non-vegetarian food (meat, chicken and beef) slaughtering is one of the world's most rapidly increasing food industries. The wastes produced in the slaughterhouse are rapidly causing unhygienic conditions and pollution in and around the civil area. In this way, while meeting the food requirement of people, it is also causing a threat to health. Using natural resources is one of the essential innovations in producing energy. Biodiesel is a valuable renewable energy source because it is biodegradable and non-toxic.

**Methods:** This study aims to upgrade the reformation of fat residues of *Capra hircus* into biodiesel by using 0.96% wt KOH as a catalyst. The waste organs, including stomach, skin and fatty residues, were brought locally in the meat shop. Fat contents were extracted in ethyl alcohol from the waste organs through the Soxhlet apparatus and purified with a rotary evaporator. The crude biodiesel was obtained from animal fat through a trans-esterification reaction. The animal fat and crude biodiesel sample were quantitatively analyzed using FT-IR spectroscopy.

**Result:** In the fat sample range of peak value between 3552.28 to 2974.23 $cm^{-1}$ is recognized to -C=CH (C is double bond stretching) was represented to monounsaturated fatty acid (MUFA). Furthermore, the crude biodiesel is monitored by the intensity of the C-O ester Peak at 1742.72 $cm^{-1}$. Finally, we concluded that obtained sample *via* trans-esterification reaction is biodiesel.

**Key words:** Biodiesel, *Capra hircus*, Fat, FT-IR spectrophotometer, Soxhlet.

## INTRODUCTION

India has more than 1,176 slaughterhouses and 75 modern abattoirs; from hundreds of illegal slaughterhouses, slaughterhouses produce a massive amount of solid waste released into the environment. Livestock waste is a significant source of greenhouse gas, pollution, pathogens and odour. 40% of global methane is produced by agriculture and livestock by-products, followed by 18% from waste disposal globally (EPA, 1998). The globe's meat production from pork, beef and poultry is 42.7%, 23.9% and 33.4%, respectively, including non-edible organs. These non-edible organs are a great energy source because they produce different valuable products such as fat, collagen, keratin *etc.* The visceral organs of *Pila globosa* were used to produce biodiesel as an alternative fuel source (Deshpande Sadhana *et al.*, 2015). In recent years, there has been rising interest in biodiesel for its use as a chemical addition or substitute to petroleum-based diesel fuel (Anildo Cunha *et al.*, 2013). Biodiesel is one of the essential sustainable alternate bioenergy source (Karmakar Anindita *et al.*, 2017). In recent years, bioenergy has drawn attention as a sustainable energy source because of growing energy needs, rising oil costs, the pursuit of clean, renewable energy sources and boosting farm income in developed countries (Vignesh *et al.*, 2013). Among the bio-fuels, biodiesel seems to be at the forefront because of its environmental credentials, such as renewability, biodegradability and clean combustion behavior (Tau Dong *et al.*, 2016). Fatty acids are the primary component of lipids and play a crucial role in a biological system. Fatty acids can exist as accessible and bound forms, such as cholesterols and phospholipids (Benjamins *et al.*, 2012). The fatty residues are extracted by using ethanol. The sugarcane industry waste was utilized to produce ethanol (Sing *et al.*, 2012). The vegetable oil is used to produce biodiesel and it analyzes with the help of FT-IR spectroscopic techniques and compared with the standard value (Lawan *et al.*, 2019; Holcapek *et al.*, 1999).

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## MATERIALS AND METHODS

### Collection and separation of waste organ sample

The 250 gm waste organs, including fatty residues of *Capra hircus*, were brought locally from a meat shop. The sample is collected from Mulund East and is identified in the Department of Zoology, KET'S V.G. Vaze College

(Autonomous), Mumbai. The collected samples (stomach, skin, fat bodies *etc.*) were washed with fresh water to remove sand and external debris. The cleaned sample was stored in the refrigerator at 4°C and used to extract fat (Anandganesh, 2016). Further experimentation processes were conducted in the Department of Zoology, Vidya Pratishthan's Arts, Science and Commerce College, Baramati. The present work was carried out during the year 2021-22.

**Extraction of fat residues**

Some traditional methods such as the Soxhlet method, Floch, Bligh and Dyer with particular combinations of organic solvents are used for the oil extraction. The Soxhlet apparatus mainly consists of three compartments: a flask, extraction chamber and condenser (Hewavitharana *et al.*, 2020). First, the visceral organs, including fat bodies, were chopped into small pieces using a fine blade. Next, the chopped pieces of the 250 gm sample were placed in a porous thimble for fat extraction. Finally, add the 200 ml of ethyl alcohol to a 500 ml round bottom flask of the soxhlet apparatus (Benjamin *et al.*, 2019). The alcoholic fat sample was collected within 24 hours through the Soxhlet apparatus.

**Recovery of solvent from sample by rotary evaporators**

Extracted fat samples separated extracted fat and solvent through a rotary evaporator (Nor *et al.*, 2018). After separation, the solvent is collected in a separate chamber and the mass of the fat sample remains measured and carried for the Purification. The 38 gm of fat sample and 98 ml of ethyl alcohol were reutilized with the help of an evaporator.

**Analysis of fatty residues by FT-IR spectrophotometer**

The extracted fat sample was analyzed with the help of Fourier Transform Infrared Spectroscopy (FT-IR) spectroscopic techniques (Rohman *et al.*, 2011). The different graphical peak values were compared with the help of traditional values as described in Table 1.

**Trans-esterification reaction for the production of crude biodiesel**

A pre-treatment is needed for producing biodiesel from animal fat because it contains a high amount of free fatty acid (FFA) and water, reducing biodiesel yield (Gebremariam *et al.*, 2018). Biodiesel is produced through a trans-esterification reaction. Different catalysts are available for biodiesel production (Fidel *et al.*, 2020). Those most typically used trans-esterification reactions are alkalis (sodium hydroxide, sodium methoxide, potassium hydroxide, potassium methoxide, sodium amide, sodium hydride, potassium amide and potassium hydride), acids (sulfuric acid, phosphoric acid, hydrochloric acid or organic sulfonic acid), heterogeneous catalysts like enzymes (lipases) and complex catalysts like silicates, zirconias, nanocatalysts, *etc.* (Fidel *et al.* 2020). Sodium and potassium hydroxides run pretty well and methoxides perform better but are more expensive (Atabani *et al.*, 2012). For trans-esterification of refined sunflower oil treated with ethanol using potassium hydroxide (Kumar *et al.*, 2014). So, we prefer the 0.96% wt. Potassium hydroxides as the catalyst. So, for the trans-esterification reaction, 36 gm. animal fats are treated with 100 ml ethyl alcohol in the presence of potassium hydroxide and produce the two compounds respectively, 32 ml biodiesel and 65 ml glycerol. After the trans-esterification reactions, a prepared sample that is added into the separating funnel and separates the biodiesel and glycerol sample later is stored in the laboratory.

**Estimation of crude biodiesel**

After the completion of the trans-esterification reaction, extracted samples were analyzed with the help of the FT-IR spectroscopic technique and determining the different functional groups, wavelength and intensity to confirm crude biodiesel (Holcapek *et al.* 1999).

## RESULTS AND DISCUSSION

**Accounts of samples obtained are maintained after different steps of extraction**

In the present study, the fat content was extracted from the waste organs of *Capra hircus* in ethyl alcohol solvent through the Soxhlet apparatus method (Benjamin *et al.*, 2019). The 38 gm of fat residues were produced using 250

**Table 1:** Key factors of FT-IR spectrophotometer absorption peaks for different functional groups, wavelengths ($cm^{-1}$) and intensity (Asmatula *et al.* 2019).

| Functional group | Wavelengths ($cm^{-1}$) | Intensity |
|---|---|---|
| Water OH tretch | 3700-3100 | Strong |
| Alcohol OH stretch | 3600-3200 | Strong |
| Carboxylic acid OH stretch | 3600-2500 | Strong |
| N-H stretch | 3500-3350 | Strong |
| =C-H stretch | ~3300 | Strong |
| =C-H Stretch | 3100-3000 | Weak |
| -C-H Stretch | 2950-2840 | Weak |
| -C-H aldehydic | 2900-2800 | Variable |
| C=N stretch | ~2250 | Strong |
| C=C stretch | 2260-2100 | Variable |
| C=O aldehyde | 1740-1720 | Strong |
| C=O aldehydride | 1840-1800, 1780-1740 | Weak, Strong |
| C=O ester | 1750-1720 | Strong |
| C=O ketone | 1745-1715 | Strong |
| C=O amide | 1700-1500 | Strong |
| C=C alkene | 1680-1600 | Weak |
| C=C aromatic | 1600-1400 | Weak |
| $CH_2$ bend | 1480-1440 | Medium |
| $CH_3$ bend | 1465-1440, 1390-1365 | Medium |
| C-O-C stretch | 1250-1050 several | Strong |
| $NO_2$ Stretch | 1600-1500 and 1400-1300 | Strong |
| C-F | 1400-1000 | Strong |
| C-Cl | 800-600 | Strong |
| C-Br | 750-500 | Strong |
| C-I | ~2250 | Strong |

gm of waste organs of *Capra hircus*. Then, we purified the extracted sample and got 38 gm of fatty residues and 98 ml of ethyl alcohol recovered with the help of evaporators. The 36 gm of fatty residues after extraction were preceded by biodiesel production through trans-esterification reaction. For the production of biodiesel, use 0.96% wt. KOH as the catalyst and 36 gm of fatty residues and 100 ml ethyl alcohol and got the two compounds respectively 32 ml of crude biodiesel and 65 ml of glycerin. Both of the samples were separated through a separating funnel. The extracted crude biodiesel is analyzed with the help of FT-IR Spectro photometer.

The percentage of extracted samples was calculated and represented in Fig 1. The 15.20% fat and 49% ethyl alcohol (Solvent) were removed through the separation process. The 23.18% crude biodiesel and 71.01% glycerin content were obtained through the trans-esterification reaction.

**Characterization of fat sample of *Capra hircus***

Fatty acids are an essential component of lipids in living organisms, including plants, animals and different microorganisms. Therefore, the extracted fatty residues were analyzed with the help of FT-IR spectroscopic method (Fig 2). The fourier transform Infrared Spectroscopy (FT-IR) can mainly represent the information on lipid structure and functional group (Xu *et al*., 2016).

The Spectra of the fat content of *Capra hircus* in Fig 2 recorded the different wavelength peaks. Many functional groups were recorded in FT-IR spectra of fatty residues of *Capra hircus*. It includes 3552.28 $cm^{-1}$, 2974.23 $cm^{-1}$, 2927.94 $cm^{-1}$, 2895.15 $cm^{-1}$, 1647.21 $cm^{-1}$, 1381.03 $cm^{-1}$, 1350.17 $cm^{-1}$, 1327.03 $cm^{-1}$, 1274.95 $cm^{-1}$, 1085.92 $cm^{-1}$ and 879.54 to 439.77 $cm^{-1}$ respectively. The wavelength 3552.28 $cm^{-1}$ represents the strong peak of the functional group Carboxylic acid OH stretch. The range of peak value 3552.28 to 2974.23 $cm^{-1}$ was recognized as -C=CH (Cis double bond stretching) can be correlated with monounsaturated fatty acid (MUFA) (Rohman *et al.,* 2011). The 2974.23- 2927.94 $cm^{-1}$ and 2895.15 $cm^{-1}$ wavelengths represented the -C-H Stretch and -C-H aldehydic functional groups, respectively (Table 1). The weak peak was recorded in the sample, including 1647.21 $cm^{-1}$, 1381.03 $cm^{-1}$, 1350.17 $cm^{-1}$, 1327.03 $cm^{-1}$ and

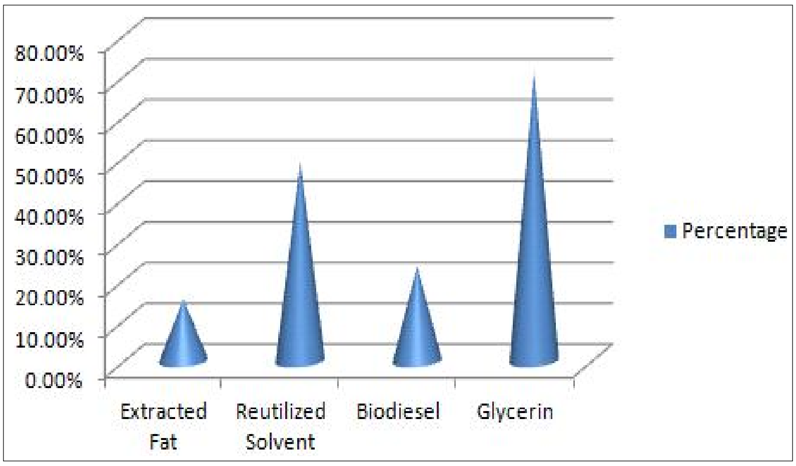


**Fig 1:** Percentage of utilized and reutilized samples.

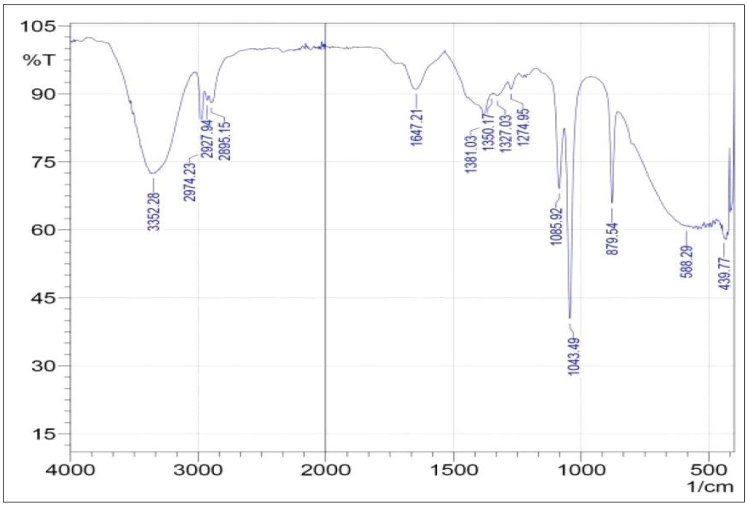


**Fig 2:** FT- IR spectra of fatty residues of *Capra hircus*.

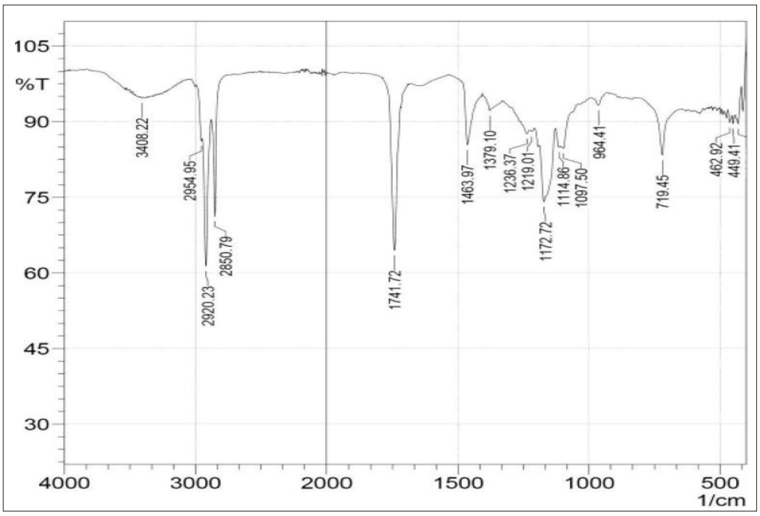


**Fig 3:** FT- IR spectra of crude biodiesel sample.

1274.95 $cm^{-1}$ representing the functional groups; for example, C=C alkene, $CH_3$ bend, C-O-C stretch and $NO_2$ Stretch (Asmatula *et al*., 2019).

**Characterization of crude biodiesel sample**

The biodiesel sample was analyzed using the FT-IR spectroscopy technique to monitor the trans-esterification reaction. The spectrum of blends of biodiesel is displayed in Fig 3. Many peaks of wavelength were recorded by FT-IR in biodiesel sample including 3408.22 $cm^{-1}$, 2954.95 $cm^{-1}$, 1742.72 $cm^{-1}$, 1463.97-1097.50 $cm^{-1}$ and 719.41-449.41 $cm^{-1}$. The most strong peak in the spectrum, the C=O ester stretch at 1741.72 $cm^{-1}$, is recorded. These peak values represent biodiesel's presence in the extracted sample (Ault *et al*. 2012).

However, the weak peaks at 3408.22 $cm^{-1}$ are representing the Alcohol OH stretch in the given sample. The other different functional groups were recorded from the FT-IR Spectrum of crude biodiesel.

## CONCLUSION

We concluded that the slaughterhouse waste organs could be used to commercialize fat content and crude biodiesel. The Soxhlet apparatus produced fat content in ethyl alcohol as a cheap solvent. The animal fat was used for trans-esterification reaction to produce two actual contents: crude biodiesel and glycerin. Finally, we concluded that Fourier Transform Infrared Spectroscopy (FT-IR) can be used to analyze animal fat at frequency regions from 4000 $cm^{-1}$-700 $cm^{-1}$ and crude biodiesel peak represented the functional group C=O ester stretches at 1742.72 $cm^{-1}$ are confirmed. Present research work utilizes the rapid and cheap method to produce animal fat and biodiesel content.

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**Conflict of interest:** None.

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