Utilization Of used oil into biodiesel by using duck bone catalyst to meet the needs of diesel fuel review

Irma Amaliah Indrianty[1*], *Suhardi*[2], and *Masjono* Muchtar[3]

[1]Agro-indutrial Engineering Students, Faculty of Agriculture, Univesitas Hasanuddin, Makassar, Indonesia.
[2]Department of Agricultural Tecnology, Faculty of Agriculture, Hasanuddin Universitas, Makassar, Indonesia.
[3]Department of Automation of Machinery Automation System Makassar ATI Polytechnic, Makassar, Indonesia.

Abstract. The growing need for oil presents a difficulty necessitates finding alternative energy sources. Since petroleum is a non-renewable resource, it requires millions, or even hundreds of millions of years to undergo transformation its raw materials into usable petroleum, the increase in the amount of petroleum consumption causes depletion of the amount of petroleum, potentially causing an energy crisis in the future. One solution is to process waste cooking oil into biodiesel as a substitute for diesel fuel. In order to generate superior biodiesel with relatively elevated quality, an investigation was conducted on the use of CaO as a solution purifier from impurities, separating glycerol and methyl ester. Most interestingly, Biodiesel can be used in existing diesel engines with minimal to no adjustments and little loss of performance. Most studies suggest that incorporating sufficient oxygen in biodiesel significantly reduces exhaust emissions.

1 Introduction

The rising need for petroleum poses a difficulty that necessitates finding alternative energy sources. As a non-renewable resource, petroleum takes millions or even hundreds of millions of years to form from raw materials. Increasing petroleum consumption leads to the depletion of oil reserves [1]. Amid the worsening energy crisis strict regulations regarding emissions within the transportation industry, especially regarding carbon dioxide emissions, the urgency to shift to cleaner fuels is intensifying. The desire to decrease environmental damage and improve sustainability has prompted the investigation into alternative fuels, including biofuels, ammonia, hydrogen, and electricity [2]. While oil reserves are dwindling and non-renewable, it has the potential to cause an energy crisis in

* Corresponding author: amaliaindriyanti@gmail.com

the future. Therefore, to overcome these problems and reduce dependence on fuel, it is necessary to diversify energy by looking for alternative renewable energy. One of them is alternative energy derived from plant oils [3].

Used cooking oil can be valuable if processed correctly. A possible approach of managing used cooking oil is converting it into biodiesel, which can serve as a substitute fuel to replace diesel [4]. The use of recycled cooking oil as a raw material for biodiesel is due to its similar characteristics to palm oil, as it still contains triglycerides and free fatty acids. Economically, low-quality used cooking oil, such as black oil, is often available for free since it is considered waste. Statistical data indicates a growing trend in cooking oil production. Besides its abundant availability, used cooking oil poses environmental risks by raising the levels of COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand) in water and generating foul odors through biological degradation [5]. This review aims to provide information about the potential of used oil, the potential of catalysts from duck bone waste, and the conversion of oil into biodiesel as an alternative fuel for diesel engines.

2 Methodology

The approach employed in this review involves conducting a literature review, which entails collecting data and information from diverse sources like journals and books. To identify academic literature, use Science Direct, Web of Science, Scopus, and relevant academic journals. The literature review primarily concentrated on articles published between 2009 and 2023., It starts with identifying an issue, then proceeds to analyze and discuss biodiesel synthesis through transesterification using different catalyst types. Table 1 collects the materials needed in the biodiesel production process. Including several catalysts that have been used in previous studies.

3 Results

3.1 Potential Of Waste Oil to Biodisel

To manufacture improved and biodiesel of relatively high qualitya, studies and development of materials employed in the manufacturing of biodiesel takes place to answer some of these problems. Based on studies, Recycled cooking oil is considered as a replacement for palm oil in biodiesel production. Used cooking oil, which is significantly more affordable than pure vegetable oil, when it comes to producing biodiesel, palm oil is equivalent to palm oil in both quality and value. The transesterification process is a widely utilized method for producing biodiesel from used cooking oil. However, several factors, such as temperature, require thorough investigation during the process [6], reaction time [7], the ratio of alcohol to oil by moles [8] and catalyst [9].

Utilizing Used cooking oil poses risks to both the environment and human health. When fried foods are prepared, the oxidation of oil is believed to generate toxic substances that can lead to cancer [10]. Used cooking oil is readily accessible, yet it is frequently neglected once use, especially after frying. The annual disposal of used cooking oil derived from both vegetable and animal fats, without proper treatment as waste, is evident. This is evidenced by the fact that a significant quantity of household-used cooking oil is disposed of in drains and soil [11]. Thus, one of the recommendations to overcome these problems is to recycled cooking oil as a cost-efficient raw material for biodiesel and environmentally friendly. Additionally, due to the growing quantity of used cooking oil, it holds promise as a raw material for biodiesel manufacturing [12].

Biodiesel, a blend of methyl esters obtained from different fatty acids is generated through a chemical process called transesterification. The main goal of transesterification is to reduce the substance's viscosity [13]. vegetable oils/fats because they mainly contain triglycerides. Figure 1 illustrates the transesterification reaction [14].

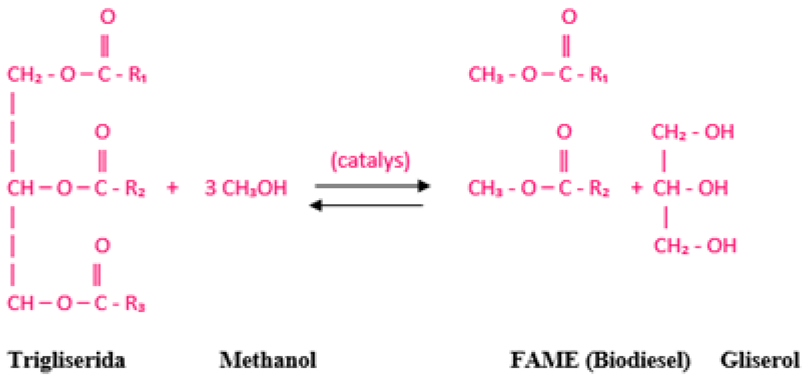

Fig. 1 the "transesterification" reaction (Adhikesavan [14])

3.2. Catalyst Potential Of Duck Bone Waste Equations And mathematics

Heterogeneous catalysts provide several benefits over homogeneous catalysts [15]. They can be easily separated from the mixture produced from the reaction through uncomplicated separation methods, such as filtration [16] or through centrifugation [17], thereby minimizing the requirement for extra purification steps. Sustainable development is now a critical global objective, with innovative reuse of waste materials being essential to its success. Employing biochar and ash catalysts in biodiesel production brings multiple advantages beyond their catalytic functions. These catalysts, derived from biomass waste, contribute to mitigating the environmental consequences associated with waste disposal. Like camel bone [18], snail shell [19] and duck eggshells [20] Furthermore, their affordability and widespread availability render them an appealing substitute for traditional catalysts, which are frequently costly and sourced from non-renewable materials [21].

In today's food industry, discarded bone waste poses a major environmental issue is the large volume of waste animal bones (WABs) produced globally. The food industry and household waste contribute significantly to this, annually, more than 130 million metric tons of slaughtered WABs [22] Compositionally, animal bone consists of 30-35% constituents of an organic nature (comprising 95% collagen and protein) and 65-70% non-organic components. Research has studied the impact of incorporating bone powder and bone ash into cement, focusing on how they affect the mechanical properties of cement mortars. WAB is a naturally occurring material abundant in apatite, comprising approximately 65-70% of the inorganic compound calcium phosphate, primarily composed of hydroxyapatite, having the chemical formula $Ca_{10}(PO_4)_6(OH)_2$. The elemental analysis indicates the apatite composition as follows: approximately 56.3% phosphate and 36.8% calcium. Converting WAB into value-added materials for industrial applications will provide economic and environmental benefits. The use of WAB as an inorganic material is gaining popularity because it is safe for storage and handling without toxicity, sourced from animal bones and shells like clams, oysters, mussels, eggshells, and sea shells [23].

The utilization of duck bone waste is currently still very little. In fact, Products of value can be derived from duck bones, including as adsorbents. In addition, from an economic point of view, duck bones still have low value. Chemically, the main components of duck bone include salts, including calcium carbonate and calcium phosphate. The main inorganic phase of bone is the crystalline mineral salt of calcium phosphate and is often idealized as hydroxyapatite, also known as hydroxyapatite [24].

The catalyst preparation process from duck bone waste is carried out through several stages. During the initial phase, the bones were rinsed using hot water several times until clean and then dried in the sun for 12 hours. The sample was subjected to further drying in an oven at a specific temperature of 100°C for a duration of 2 days. Drying the sample aims to facilitate the process of pulverizing duck bones. Sieving is done to produce duck bone powder with a small and uniform size. The second stage of duck bone powder is calcined at 700°C for 30 minutes. The dried duck bones were then pulverized and sieved until the particles passed the 80 mesh sieve. Calcination aims to remove organic compounds, release C and O elements in the shape of CO2 gas through the decomposition of calcium carbonate (CaCO3) contained in duck bones so that calcium oxide (CaO) compounds are obtained. The calcined duck bones were then cooled in a desiccator, and stored in a closed container. [24-25]

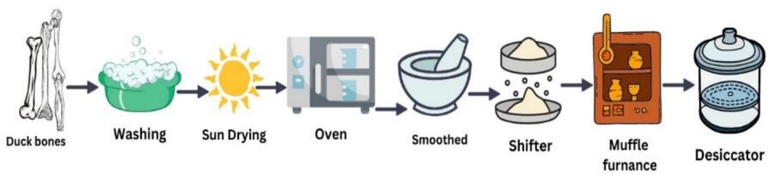

Fig. 2 Schematic diagram of catalyst manufacturing process

3.3 Oil Processing Into Biodisel

Several techniques, such as pyrolysis, microemulsification, and transesterification, are available for producing biodiesel from refined or used cooking oil. Transesterification, a widely adopted method in biodiesel production, involves combining combining oil and alcohol, in the presence of a catalyst, initiate a reaction yielding alkyl esters alongside glycerol as by-products.. This three-step process starts by converting triglycerides into diglycerides, then further converting diglycerides into monoglycerides, and ultimately converting monoglycerides into glycerol. Each reaction step produces three ester molecules from each glyceride molecule [12].

Glycerol, a secondary product generated during the biodiesel production process, is a desirable resource, whether used as the primary carbon source or added to the production medium to enhance lipid accumulation [26]. To achieve optimal biodiesel production, it is essential to carefully optimize key process variables such as “methanol” quantity, the amount of catalyst used, the temperature of the reaction, and the duration of the reaction [27].

Catalysts are crucial in biodiesel production, with two types being commonly used: homogeneous and catalysts that are not uniform in composition. Heterogeneous catalysts gained significant interest primarily because they can be readily removed from the reaction mixture after the process is finished. Lately, customized mineral catalysts have shown efficacy in biodiesel production. These catalysts can be customized for particular uses and optimized to enhance their effectiveness in converting oil into biodiesel [28].

Nowadays, The adoption of heterogeneous catalysts is viewed as an environmentally sustainable option to tackle the disadvantages associated with homogeneous catalysts. Heterogeneous catalysts provide benefits such as easier separation through filtration, high recovery rates, longer lifespan, tolerance to water or free fatty acids in some cases, reduced saponification, and elimination of the washing process, thereby mitigating environmental concerns [29].

Table 1 Materials required for the biodiesel production process

Sample	Solvent	Catalyst	Yield	Reference
Waste cooking oil	Methanol	Egg shell	NA	[20]
Parkia biglobos	methanol	Clay	94,7%	[30]
Waste cooking oil	methanol	Snail shell	80%	[19]
Waste cooking oil	methanol	Zeloit nature	93%	[31]
Date palm seed oil	ethanol	Camel bone	89%	[18]
Waste cooking oil	methanol	Periwinkle shell	91,5%	[32]
Triloba asimina seed oil	methanol	Wood ash powder	98,73%	[33]
Palm oil	methanol	Straw ash	96,49%	[21]
Pyrus glabra seed oil	methanol	Hidroksiapatit biokompatibel	89,21%	[34]
Pithecellobiun dulce seed oil	methanol	NaOH	96,6%	[35]
Watermelon waste oil	Ethanol	Sodium sulfate	96,76%	[36]
Soybean oil	methanol	KIT_6	98%	[37]
Catfish oil	Isopropanol	KOH	98,96%	[38]
Palm oil	methanol	KOH	94,48%	[39]

NA = Not Available

Preparation he equipment and materials used in producing biodiesel from used cooking oil include an oven, crusher, muffle furnace, desiccator, hot plate, analytical balance, GC-MS (Gas Chromatography-Mass Spectrometry), TLC/KLT (Thin-Layer Chromatography/Kieselguhr G plate), Cannon-Fenske viscometer, opaque viscometer, vacuum pump, Erlenmeyer flask, and a magnetic stirrer, previously used cooking oil and chicken eggshell adsorbent catalyst. Furthermore, the stages of making biodiesel made from used cooking oil are as follows;

1. Weighing 200 grams of filtered used cooking oil, followed by adding 60 grams of methanol and 4 grams of CaO catalyst. The mixture was agitated a magnetic

stirrer, and the temperature was gradually changed until and maintain approximately 60 degrees Celsius for 7 hours.

2. Subsequently, The blend was allowed to sit undisturbed for a full day. until it It divided into three layers: biodiesel on the uppermost layer, glycerol in the center., and the catalyst at the bottom.
3. The biodiesel and glycerin, along with the catalyst, are separated and transferred to a separate containe.
4. A small quantity of water is introduced into the biodiesel mixture intended washing process, and it is left overnight.
5. The biodiesel undergoes multiple washes until the wash water is free of soap and appears clear.
6. The biodiesel is subsequently heated to 60 degrees Celsius for 10 minutes to eliminate any residual water content [40]

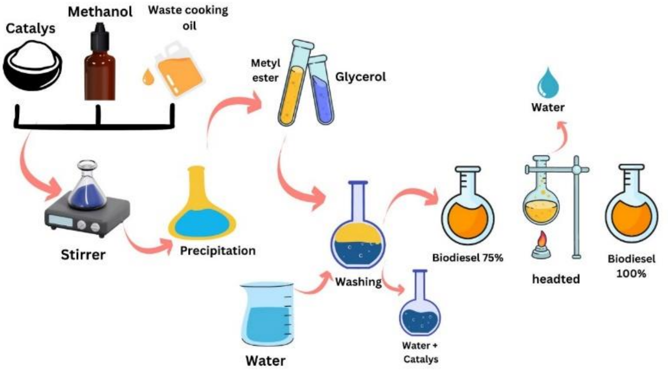

Fig. 3 Schematic diagram of biodiesel production process

3.4 Biodiesel As A Substitute Energy Source In Diesel Engines

As mineral reserves dwindle and environmental issues such as global warming grow more pressing, the importance of renewable, clean, and sustainable biofuels is increasing. In some global areas, biodiesel makes up to 30% of diesel fuel and can be utilized in diesel engines without requiring any alterations. Currently, Malaysia and Indonesia have implemented biodiesel blends like B10, B20, and B30, with Indonesia aiming to move to B40 by 2022 and Malaysia planning to achieve B30 by 2025 [41] Biodiesel is recognized as an alternative fuel due to its sustainability, absence of sulfur, and lower emissions of pollutants. The primary obstacle to its widespread adoption, however, is its higher cost compared to conventional diesel. Nonetheless, The economic efficiency of utilizing waste cooking oil (WCO) as a raw material renders it the most effective source for biodiesel production. [42]

Biodiesel and its mixtures with diesel fuel studied to tackle concerns related to fossil fuel depletion and environmental impact. Biodiesel, an alternative to diesel fuel, is usually a methyl or ethyl ester created from plant oils or animal fats using transesterification. Tests were conducted on engines using biodiesel derived from used cooking oil to evaluate engine performance. Incorporating 20% biodiesel from used cooking oil led to increased fuel consumption per unit and decreased thermal efficiency [43] for mixtures of biodiesel in comparison to conventional diesel. Nevertheless, biodiesel exhibits drawbacks such as lower energy content, increased viscosity, and higher density. Researchers have noticed that as the concentration of biodiesel in the blends rises, there is an uptick in the fuel consumption per unit of brake horsepower. Higher concentrations of biodiesel do not perform as effectively as diesel in standard engines, necessitating modifications to accommodate these blends [44].

Transesterification is an effective way to decrease the viscosity vegetable oil and address operational and durability issues. In a diesel engine operating at 1500 revolutions per minute under various loads, biodiesel produced from recycled cooking oil was tested. The exhaust gas temperature of blends containing biodiesel rose with higher concentrations of biodiesel in the mixturesThe performance characteristics of biodiesel blends made from recycled cooking oil closely mirror those of diesel. However, the energy content of biodiesel obtained from used cooking oil is approximately 15% less than that of diesel. As the proportion the manufacturing of biodiesel using waste cooking oil increases in the biodiesel blend, Furthermore, the engine's exhaust gas temperature rises when fueled with the blend. Moreover, higher specific fuel consumption occurs with biodiesel blends exhibit lower heating values compared to diesel fuel, contributing to increased fuel usage. Additionally, the efficiency of heat utilization in biodiesel blends decreases with higher proportions of biodiesel, indicating the need for engine adjustments to accommodate these blends [45].

This occurs due to the utilization of biodiesel fuel is consisting of methyl esters of fatty acids, biodiesel is notably more readily evaporate compared to the hydrocarbons found in diesel fuel. Consequently, biodiesel evaporates more rapidly and thoroughly, resulting in lower levels of hydrocarbons in the exhaust gases [46]. Emulsions in general produce minimal hydrocarbon emissions compared to diesel, probably caused by the micro-explosion of water trapped inside fuel droplets within the combustion chamber, thereby improving fuel combustion [46]. The study proposes that using oil palm mesocarp cells together with hydrogen gas shows potential for diesel engines. Nevertheless, further research is necessary to establish its effectiveness and its impacts on the exhaust emissions produced from burning biodiesel and hydrogen [47].

Many researchers have explored biodiesel as a practical alternative to diesel fuel. Research indicates that biodiesel holds significant promise for several reasons, including its high biodegradability and low toxicity. Moreover, biodiesel performs better than diesel in terms of reduced combustion emissions and operates within a closed carbon cycle, thereby not contributing to global warming. One of its most notable advantages is its compatibility with current diesel engines with minimal or no modifications, and with little loss in performance. Numerous studies consistently demonstrate substantial reductions in exhaust emissions, particularly CO, CO^2, SO^2, hydrocarbons, particulates, and smoke, attributed to thorough combustion facilitated by the abundant oxygen content in biodiesel. [12] Oxidation stability refers to the capacity of a fuel to withstand deterioration while stored [48] Before undergoing oxidation due to exposure to oxygen, it does not affect engine operation or emissions [49]

4 Discussion

According to current research, catalyst materials derived from biomass waste can contribute significantly to alleviating the environmental impact of waste disposal. Various organic waste materials such as camel bones [18], snail shells [19], and duck egg shells [20] have been identified as potential sources of such catalysts. These materials, which are often discarded as waste, can be repurposed into valuable resources, thereby reducing the volume of waste that needs to be managed and mitigating the associated environmental problems.

The appeal of using these biomass-derived materials lies in their affordability and widespread availability. Traditional catalysts, which are often derived from finite resources, can be expensive and less sustainable in the long term. By contrast, biomass waste is generally abundant and inexpensive, making it a more economically viable option for large-scale applications. The use of these alternative materials not only provides a cost-effective solution but also promotes the conservation of non-renewable resources [21].

One specific type of biomass waste that holds promise for catalytic applications is duck bone waste. Despite its potential, the utilization of duck bone waste is currently minimal. Duck bones contain calcium phosphate, primarily in the form of hydroxyapatite, which is known for its adsorptive properties. These properties can be harnessed to create effective adsorbents for various industrial processes. The potential uses of duck bone waste as an adsorbent highlight the untapped value of this material and the opportunities for further research and development in this area [24].

In addition to its use as an adsorbent, duck bone waste could also serve as a catalyst for biodiesel production. However, there are currently no reports on the process of making biodiesel using catalysts derived from duck bone waste under any conditions. This gap in the research presents an opportunity for scientists and engineers to explore and develop new methods for converting duck bone waste into effective biodiesel catalysts. By doing so, they could contribute to the advancement of sustainable energy production and waste management practices.

Overall, the exploration of biomass waste-derived catalyst materials offers a promising avenue for reducing the environmental impact of waste disposal and promoting sustainable industrial practices. By investigating and utilizing materials such as camel bones, snail shells, and duck egg shells, as well as exploring the potential of duck bone waste, researchers can develop innovative solutions that address both economic and environmental challenges. The continued study and application of these materials will be crucial in advancing sustainable technologies and reducing our reliance on finite resources.

5 Conclution

Petroleum, being a non-renewable energy source, diminishes as its consumption increases. Therefore, to overcome this problem and reduce dependence on fuel, it is essential to diversify energy by utilizing used cooking oil into biodiesel, as a renewable energy. In order to manufacture superior and comparatively elevated biodiesel, a study was conducted on the utilization of CaO as a solution purifier from impurities, separating glycerol and methyl ester [50] Biodiesel is recognized as an alternative fuel due to its sustainable nature, lack of sulfur, and reduced emissions. What makes biodiesel particularly appealing is its ability to be used in existing diesel engines with minimal to no modifications, resulting in negligible performance loss. Multiple studies have consistently demonstrated significant reductions in exhaust emissions, especially compared to diesel fuel, including CO, CO^2, SO^2, hydrocarbons, particulates, and smoke. This is because biodiesel promotes thorough combustion due to its high oxygen content, resulting in reduced emissions.

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