BIODIESEL PRODUCED

A Study on Storage Stability of Biodiesel Produced from Waste Cooking Rice Bran Oil (WCRBO)

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Abstract

Due to decrease in petroleum reserves and the environmental pollution caused by fossil fuels, biodiesel is becoming increasingly popular in today's society. Because waste cooking oil (WCO) is easily available, it is a great option for making biodiesel. In addition, it is not good for your health to ingest used oil, and getting rid of it can harm the environment. As a result, rather than being disposed of, WCO is utilized in the production of biodiesel. In this study, waste cooking oil is converted to biodiesel.

The aim of this research is to evaluate the storage stability of WCRBO biodiesel for sixty days under different storage conditions, including light and dark settings. Regularly assessing the storage stability of biodiesel involves measuring its flash point, fire point, acid value, peroxide value, and viscosity. Oxidation is closely connected to external factors such as light, temperature changes, and humidity levels. These circumstances led to a faster oxidation of biodiesel.

Keywords: Waste Cooking Oil; Waste Cooking Rice Bran Oil; Transesterification; Storage Stability

1 Introduction

Biodiesel is a type of fatty acid alkyl ester produced from biological sources such as vegetable oil, animal fat waste, and algae. Biofuel made from sustainable sources, such as biodiesel, is the primary form of renewable energy. The researchers utilized the alkaline catalyzed transesterification method due to its speed, high yield, mild reaction conditions, low cost, and reduced corrosiveness and toxicity. Transesterification is the term for replacing the organic group of an alcohol with the organic group of a triglyceride. Chemical transformations known as transesterification are carried out by using a catalyst, which can be either acidic or basic. Enzymes can be utilized to carry out transesterification. In this work, the analysis of the variations of some important properties of waste cooking rice bran oil biodiesel over a period of time has been done. The storage of biodiesel has been found to impact its stability.

The storage stability of biodiesel determines how long it can safely be stored and how it might break down when exposed to extreme conditions. The utilization of biodiesel depends on its shelf life. Due to the presence of double bonds and specific functional groups in biodiesel molecules, it is anticipated that the problem of degradation during storage will be more serious compared to conventional petroleum-derived diesel.

As a consequence of being composed of ester chemicals, biodiesel has a higher likelihood of breaking down into alcohol and acid when it comes into contact with air or oxygen [7]. Alcohol decreases flash point, whereas acid increases acid quantity. Feed stocks refer to any biomass which are renewable

and are destined for conversion to energy to form fuel or can directly be used as fuel. In this work waste cooking rice bran oil has been selected as the feedstock.

2 Materials and methods

This study used Waste Cooking Rice Bran Oil (WCRBO) as the feedstock for transesterification based biodiesel production. The required WCRBO was supplied by a nearby college canteen, where it was used daily to fry papads. The oil was filtered to remove solid contaminants using filter paper. Transesterification is used to conduct experimental reactions in a batch stirred reactor. Here, methanol was used as the reactant alcohol, and KOH was used as the alkali catalyst.

2.1 Physico-chemical properties of feedstock and produced biodiesel

The physico-chemical properties of the feedstock (WCRBO) have been determined following ASTM methods as shown below in table 1.

Table 1. Physico-chemical properties of the feedstock (WCRBO).

Serial No	Property	ASTM Methods	Instrument used	Value	Unit
1	Acid Value	ASTM T664	Titration kit	0.5825	mg KOH/gm
2	Density	ASTM D1298	Pycnometer	0.814	g/cm^3
3	Saponification Value	ASTM D94-07	Reflux Condenser	241.83	mg KOH/gm
4	Viscosity	ASTM D445	Rheometer	41.56	centipoise
5	Flash Point	ASTM D92	Pensky Martens Apparatus	270	^oC
6	Fire Point	ASTM D92	Pensky Martens Apparatus	204	^oC
7	Cloud Point	ASTM D2500	Pour Point Tester	15	^oC
8	Pour Point	ASTM D97	Pour Point Tester	15	^oC
9	Calorific Value	ASTM D240	Bomb Calorimeter	8471.741	kcal
10	Free Fatty Acid(FFA) Value	ASTM T664	Titration kit	0.29125	

The physico-chemical properties of the produced biodiesel have been determined and compared with the ASTM standard values as shown below in table 2.

Table 2. Physico-chemical properties of WCRBO biodiesel.

SL. NO	Properties	ASTM Standard Values		Obtained values of WCRBO Biodiesel
Conventional Diesel	WCRBO Biodiesel			
1.	Density(g/cm^3)	820-860	860-890	897

SL. NO	Properties	ASTM Standard Values		Obtained values of WCRBO Biodiesel
2.	Acid Value (mg.KOH/G)	0.180	0.480	0.430
3.	FFA content(mg.KOH/g)	0.090	0.240	0.119
4.	Calorific Value(KJ/kg)	45500	42835	41782
5.	Kinematic viscosity(mm^2/s)	1.81	1.9-6	4.275

2.2 Storage stability analysis of biodiesel

The storage stability of biodiesel is its capability to preserve its chemical and physical characteristics during storage. Storing biodiesel for long-term is crucial for market viability and distribution. To evaluate the long-term storage stability, the fuel samples were stored in sealed glass vessels. The dark samples were stored in a dark wooden cabinet away from sunlight and moisture, while the others were simply left exposed. After every 15 days, measurements for acid, peroxide, and viscosity were taken. The storage stability of biodiesel was evaluated over a period of 60 days based on three parameters: acid content, peroxide content, and viscosity.

2.3 Flash point and fire point of biodiesel

The term flash point refers to the lowest temperature at which a fuel can ignite and create a flame. When dealing with biodiesel, it is crucial to take into account its flash point value for safe handling and storage purposes. The Pensky Martens apparatus measures the flashpoint of biodiesel.

The temperature at which the vapor from a liquid fuel will burn for at least 5 seconds after being ignited is known as the fire point of the fuel. This characteristic is crucial in fuels because it indicates how well the fuel can maintain combustion.

The apparatus had a copper cup that could hold 50 ml of fuel. The cup was placed in a bath filled with water. The water bath was heated gradually by a heater. A thermometer was inserted through an opening provided at the top lid of the cup in order to observe the regulated temperature rise rate at 5-6 ℃ per minute. The fuel inside the cup was stirred between 90-120 r.pm. A test flame was applied from time to time to the open space. The test flame was lowered for 1 second into the opening provided in the lid to contact the vapour.

The flash point is noted when a flash is observed in the fuel vapour upon contact with a flame, while the fire point is noted when fire is observed in the fuel vapour after at least 5 seconds of contact with a flame.



Figure 1. Pensky-Martens apparatus.

2.4 Acid value

Biodiesel contains fatty acids, which possess carboxylic acid groups within them. The acid number test detects the presence of carboxylic groups in chemical compounds. Simply put, the test assists in determining the fatty acid status within biodiesel. The procedure for the test is straightforward. In order to determine the acid number of biodiesel, a mixture of five grams of biodiesel and 125 milliliters of isopropyl alcohol was prepared. The blend was adequately stirred for mixing before being warmed. Phenolphthalein was included for use as an indicator. Next, the solution underwent titration with 0.1N potassium hydroxide solution. The solution's endpoint was signaled by the emergence of the pink hue. In the same way, a single reading with no oil in the mix was also recorded.

$$\text{Acid value} = \frac{(A - B) \times N \times 56.1}{W} \quad (1)$$

where A = amount of 0.1 N KOH for titration with oil, B = amount of 0.1 N KOH for a blank sample, N = normality of KOH and W = weight of oil.

2.5 Peroxide value

Oxidative stability measure of oils is determined by the value of peroxide. It assesses the levels of hydro peroxides and peroxide content produced in the initial phase of biodiesel oxidation. 20 ml of acetic acid and 10 ml of chloroform were placed in a flask. The mixture was gently shaken to ensure proper mixing after adding 5 gm of oil. After adding 0.5 ml of KI solution to the flask, the solution was stirred gently. The solution transformed to a golden hue. In the mixture, 30 ml of distilled water turned it into a deep yellow color. When the starch indicator (0.5ml) is added, the solution turns

black. The solution was titrated with 0.1 N sodium phosphate until the black color vanished. In the same way, a single empty reading was established without any oil.

$$\text{Peroxide value} = \frac{(S - B) \times N \times 1000}{W} \quad (2)$$

where S = amount of titrating solution required for titration with oil, B = amount of titrating solution required for titration without oil, N = normality and W = weight of oil.

2.6 Viscosity

Viscosity is the measure of a liquid's internal resistance to flow when one component moves over another. Initially, 50 ml of biodiesel was warmed to a temperature of 80ºC. Next, the warmed biodiesel was transferred into the Redwood Viscometer's cup. The opening at the base of the cup was uncovered. The duration was observed until the mug was drained. This determined the dynamic and kinematic viscosity values.

$$\text{Kinematic viscosity} = At - \frac{B}{t} \quad (3)$$

Table 3. Values of A and B with respect to flow time.

Time (sec)	A	B
34-100	0.0026	1.72
above 100	0.00247	0.5



Figure 2. Redwood viscometer.

3 Results and discussion

Following the waste cooking rice bran oil biodiesel preparation, it was split and placed into two individual sample jars for storage. One sample was kept under light conditions while the other was stored in darkness without any light present. Afterwards, the samples were assessed for storage stability by measuring specific properties of the fuel at set time intervals. The acid number, peroxide value, kinematic viscosity, flash point, and fire points are assessed biweekly. The data collected will be displayed in a graph to demonstrate the fluctuations in fuel characteristics over time and in different weather conditions, as well as to illustrate the impact of these variations on the fuel's stability during storage over a specific timeframe.

3.1 Variation of flash point with time (days)

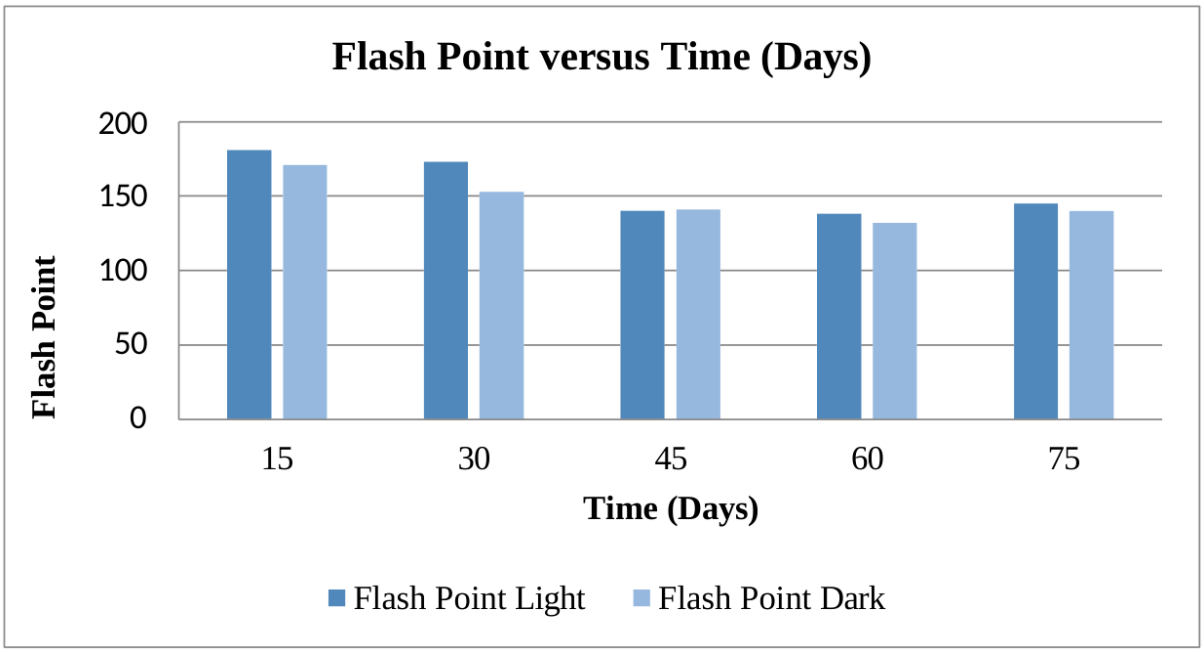

Figure 3. Flash point versus time (days).

Figure 3 displays the flash point graph, which indicates how likely a sample, is to create flammable mixtures with air in a controlled laboratory setting. As a result, it functions as an indicator of the fuel's combustibility and, thus, a crucial safety consideration.

Figure 3 demonstrates the variation of flash point values over time. The illustration reveals that the sample of waste cooking rice bran oil biodiesel stored in regular atmospheric conditions exhibited a reduction in flash point, which slightly increased following a change in weather.

Initially, the flash point values decreased as the ambient temperature and humidity decreased gradually during the approach of winter. When the weather shifted, it caused a rise in ambient temperature and humidity, subsequently leading to increased oxidation reactions in biodiesel samples. The value had gone up over time for both samples stored in Light and Dark conditions.

The degradation rate of biodiesel was found to be higher in Dark conditions compared to Light conditions. Compared to the Light condition, the Dark condition had the same temperature and humidity level, but slightly higher. Due to a small temperature variation, the specimen experienced increased oxidation.

3.2 Variation of fire point with time (days)

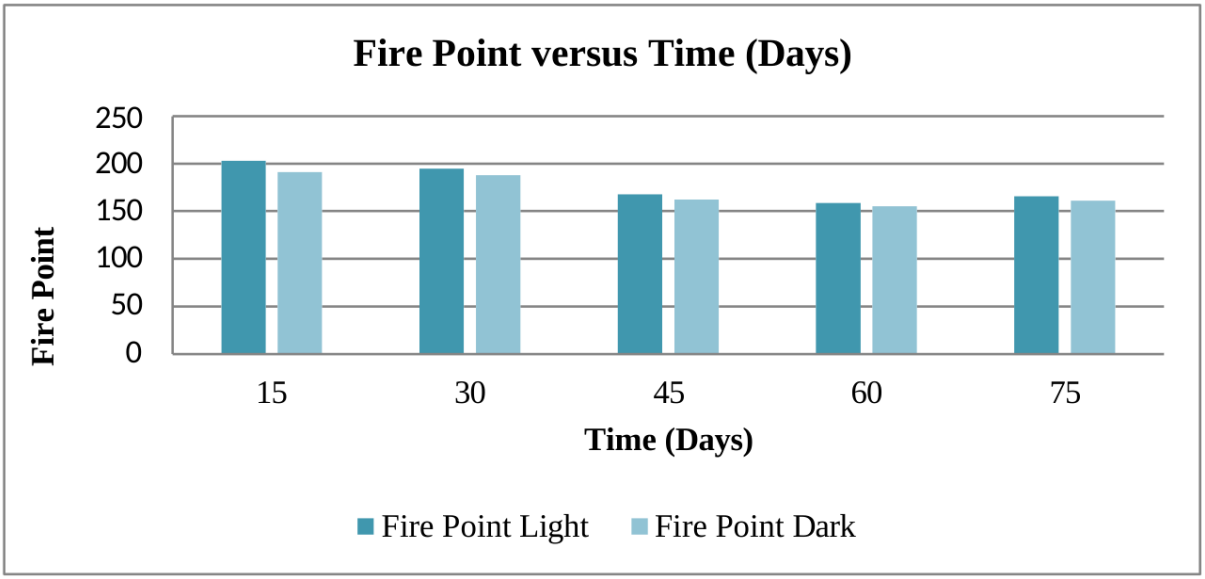

Figure 4. Fire point versus time (days).

The fire point is the temperature at which the vapor from a liquid fuel can sustain a flame for a minimum of 5 seconds after being lit. This characteristic is crucial for fuels because it shows how well the fuel can maintain combustion.

The diagram in Figure 4 illustrates the variation of fire point values over time. The figure displays that the waste cooking rice bran oil biodiesel sample stored in regular atmospheric conditions had a lower fire point initially, which slightly increased after a change in weather.

Initially, the fire point values started to decrease as the temperature and humidity dropped steadily with the onset of winter. Changes in weather led to elevated ambient temperature and humidity levels, which subsequently resulted in increased oxidation reactions in biodiesel samples. The value had gone up over time for both samples stored in Light and Dark conditions.

The rate of biodiesel degradation was noticed to be higher in Dark conditions compared to Light conditions. The temperature and humidity levels in the Dark condition were the same as in the Light condition, but slightly elevated. The sample experienced increased oxidation due to a small temperature variation.

3.3 Variation of acid value with time (days)

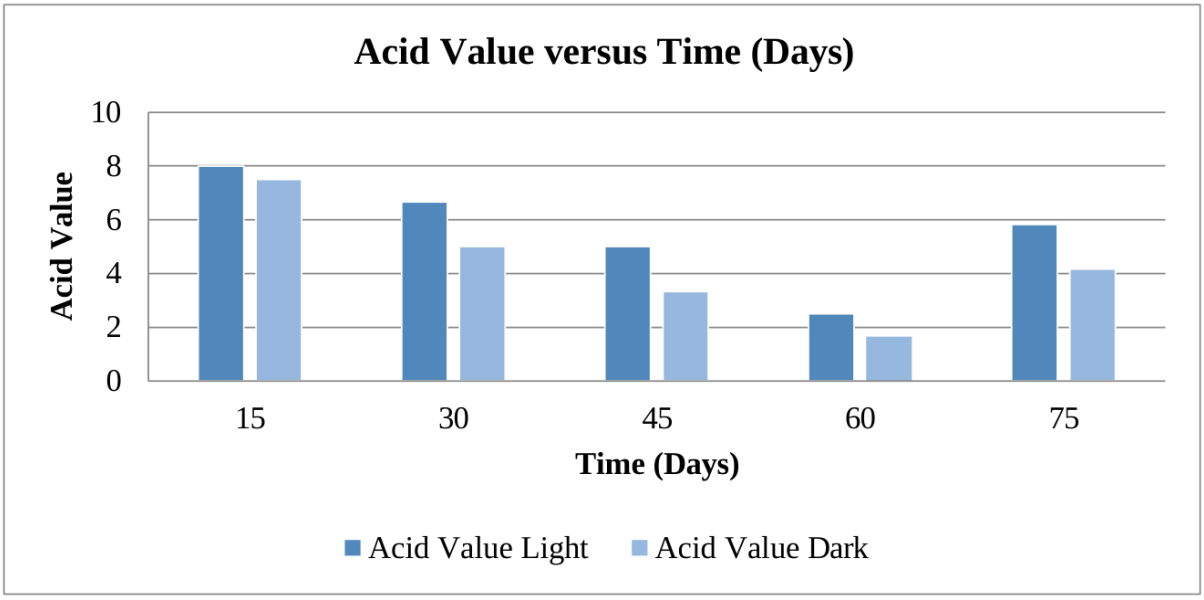

Figure 5. Acid value versus time (days).

The acid value chart shows the level of leftover mineral acid, leftover free fatty acid, and organic acids in biodiesel due to oxidative degradation during a certain period of storage. During oxidation, the fatty acid decomposes into shorter chain acids, which causes the acid number to increase. It is important to prevent a high acid content in the fuel as it can lead to severe damage in the engine's fuel supply system.

The diagram in figure 5 represents the variations in acid value over time. The data demonstrates that waste cooking rice bran oil biodiesel sample stored in regular atmospheric conditions exhibited a drop in acid value, followed by a slight increase post weather change.

Initially, the acid levels showed a tendency to decline as the temperature and humidity dropped gradually with the onset of winter. This implied that the oxidation reactions were decelerating and that the stability was enhancing. Increased oxidation reactions in biodiesel samples were a result of elevated ambient temperature and humidity levels caused by changes in weather. The value had gone up over time in storage for both samples under Light and Dark conditions.

The biodiesel degradation rate was found to be higher in Dark conditions compared to Light conditions. Compared to the Light condition, the Dark condition had temperatures and humidity levels that remained constant and were slightly elevated when compared to the Light condition. The minor temperature variation caused increased oxidation in the sample.

3.4 Variation of peroxide value with time (days)

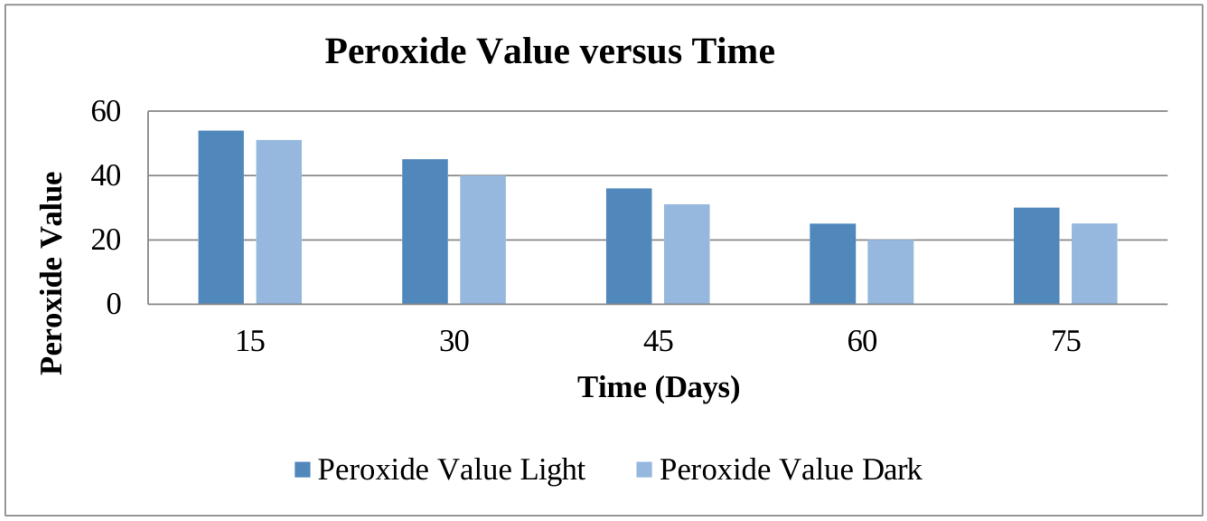

Figure 6. Peroxide value versus time (days).

The peroxide value assesses the quantity of unstable hydro peroxide in deteriorated biodiesel, resulting from the reaction of oxygen from the air with fatty esters (oxygenated fatty esters). This indicates the absorption of oxygen into the chemical composition of biodiesels in the form of oxygenated fatty compounds. Since these oxygenated fatty compounds are inherently unstable, they are frequently the initial stage in the breakdown process of biodiesel fuel due to oxidation. An elevation in peroxide value leads to a rise in cetane number that could decrease ignition delay time.

The diagram in figure 6 illustrates the fluctuation of peroxide value over time. The data shows that the peroxide value of waste cooking rice bran oil biodiesel decreased under normal atmospheric conditions, but slightly increased after a change in weather.

Initially, the levels of peroxide values exhibited a decline as the temperature and humidity dropped steadily with the onset of winter. This indicated that the rate of oxidation reactions was decreasing and the level of stability was increasing. The shift in weather caused a rise in ambient temperature and humidity levels, leading to an increase in oxidation reactions in biodiesel samples. The value had risen over time in storage for both samples exposed to Light and Dark conditions.

The rate of biodiesel degradation was found to be higher in Dark conditions compared to Light conditions. The temperature and humidity levels in the Dark condition were similar to those in the Light condition, but slightly higher. The sample experienced increased oxidation due to a minor temperature variance.

3.5 Variation of viscosity with time (days)

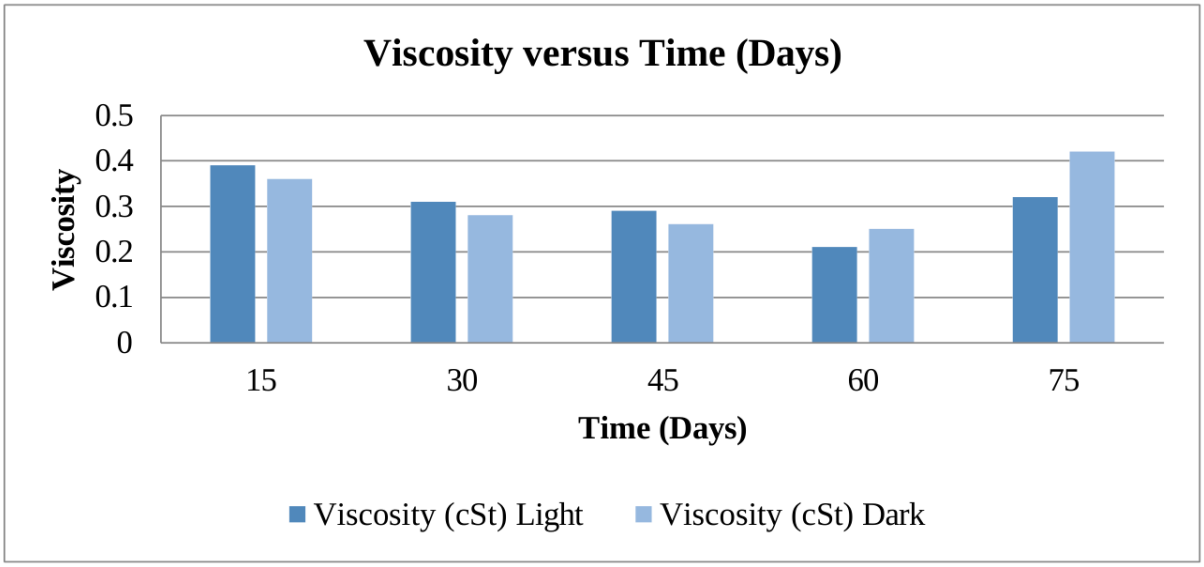

Figure 7. Viscosity versus time (days).

Viscosity is a crucial characteristic of fuel as it indicates how easily it can flow, impacting fuel injection operation, especially in cold conditions. The way the fuel acts varies based on different temperatures. Fuel that has partially or completely solidified can lead to blockages in the engine, which can cause fuel shortages and lead to issues with engine functionality.

Figure 7 depicts the variation of viscosity values over time. The figure indicates that the waste cooking rice bran oil biodiesel sample stored in normal atmospheric conditions experienced a drop in peroxide value, followed by a small increase with a change in weather.

Initially, the viscosity values showed a decreasing trend as the ambient temperature and humidity decreased gradually prior to the arrival of winter. This indicated that oxidation reactions were decelerating and stability was enhancing. When the weather shifted, it caused a rise in ambient temperature and humidity levels, leading to an increase in oxidation reactions in biodiesel samples. The value had risen over time in storage for both samples under Light and Dark conditions.

The degradation rate of biodiesel was higher in Dark conditions compared to Light conditions as observed. Compared to the Light condition, the temperature and humidity level in the Dark condition remained constant and slightly elevated. The slight difference in temperature caused the sample to experience increased oxidation.

4 Conclusion

The objective of this study was to analyze how waste cooking rice bran oil biodiesel retains quality over time during storage. This study has revealed that various elements such as temperature and length of storage can influence the stability of biodiesel when stored.

The following conclusions can be drawn from this work:

- Flash Point value decreases during the first forty five days and again increases during next fifteen days for both light and dark sample.

- Fire Point value decreases during the first forty five days and again increases during next fifteen days for both light and dark sample.
- Acid value gradually decreases during the first forty five days but shows a sharp increase during the next fifteen days for both light and dark sample.
- Peroxide value decreases during the first forty five days and again increases during next fifteen days for both light and dark sample.
- At first, the viscosity tended to decrease during the first forty five days as the ambient temperature and humidity decrease steadily as winter approached. This suggested that oxidation reactions were slowing and stability was improving. When weather changed during the next fifteen days, the ambient temperature and humidity levels increased and this increased oxidation reactions in biodiesel samples. As a result viscosities had increased with storage time for both the samples in Light and Dark conditions.

Overall, this work offers important information about the long-term storage capabilities of waste cooking rice bran oil biodiesel and emphasizes the importance of further research and advancements in this field. Additional research could prioritize improving storage conditions and creating better stabilization methods to extend the shelf life of biodiesel, thus increasing its feasibility as a substitute for conventional fuels. By overcoming these obstacles, we can speed up the acceptance of biodiesel and help create a more sustainable energy near future.

5 Scope for future work

- The transesterification process can also be experienced by varying the feedstock, alcohol and catalyst types.
- More control factors like Stirring speed of magnetic stirrer can also be introduced for the transesterification method. Moreover the effect of interactions between the factors can also be studied.
- More storage conditions can be studied.
- Developing more effective stabilization and its effects can be studied.

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References

[1] Fernandes, David M., et al. "Storage stability and corrosive character of stabilised biodiesel exposed to carbon and galvanised steels." *Fuel* 107 (2013): 609-614.

[2] Fu, Jinxia, et al. "Storage and oxidation stabilities of biodiesel derived from waste cooking oil." *Fuel* 167 (2016): 89-97.

[3] Chhabra, Mayank, et al. "Investigation of the shelf life of the optimized Neem biodiesel and its execution and excretion characteristics on automotive diesel engine." *Energy sources*, part A: recovery, utilization, and environmental effects (2021): 1-24.

[4] Jain, S., & Sharma, M. P. (2011). Optimization of long-term storage stability of Jatropha curcas biodiesel using antioxidants by means of response surface methodology. *biomass and bioenergy*, 35(9), 4008-4014.

[5] Jose, T. K., & Anand, K. (2016). Effects of biodiesel composition on its long term storage stability. *Fuel*, 177, 190-196.

[6] Bouaid, A., Martinez, M., &Aracil, J. (2007). Long storage stability of biodiesel from vegetable and used frying oils. *Fuel*, 86(16), 2596-2602.

[7] Madhurjya, Saikia. "Effect of Antioxidant on Storage Stability of Citrus Maxima Biodiesel." *International Journal of Mechanical and Production Engineering* 5.2 (2017): 49-51.

[8] Bouaid, Abderrahim, et al. "Biodiesel production from biobutanol. Improvement of cold flow properties." *Chemical Engineering Journal* 238 (2014): 234-241.

[9] Zakaria, Hanis, et al. "Effect of storage temperature and storage duration on biodiesel properties and characteristics." *Applied Mechanics and Materials* 465 (2014): 316-321.

[10] Jain, Siddharth, and M. P. Sharma. "Review of different test methods for the evaluation of stability of biodiesel." *Renewable and Sustainable Energy Reviews* 14.7 (2010): 1937-1947.

[11] Nayak, Saswat, and Uttam Kumar Sahoo. "Changes in Madhuca latifolia Macbride seed oil content and quality upon storage at different duration and condition." *Vegetos* 34.2 (2021): 422-431.

[12] Mathiyazhagan, M., & Ganapathi, A. (2011). Factors affecting biodiesel production. *Research in plant Biology*, 1(2).

[13] Narayanamoorthy, R., Sivaprakasam, S., Saravanan, C. G., Sivaraj, P., & Vikneswaran, M. (2021). Experimental investigation of 2-methyl furan as an additive with camphor blended gasoline blend for SI engines. *Fuel*, 306, 121748.

[14] Bak, Y. C., Choi, J. H., Kim, S. B., & Kang, D. W. (1996). Production of bio-diesel fuels by transesterification of rice bran oil. *Korean Journal of Chemical Engineering*, 13(3), 242-245.

[15] Alemayehu Gashaw, Tewodros Getachew and AbileTeshita , A Review on Biodiesel Production as Alternative Fuel, journal of forest products & industries, 2015, 4(2), 80-85 issn:2325–4513(print) issn 2325 - 453x (online).

[16] Ju, Y. H., & Vali, S. R. (2005). Rice bran oil as a potential resource for biodiesel: a review.

[17] Hasan, A. P., Wakil, M. A., & Kafy, M. A. (2014). Prospect of rice bran for biodiesel production in Bangladesh. *Procedia Engineering*, 90, 746-752.