Valorization of Frying Oil As Fuel (Biodiesel)

Tahri Ahmed[1], Harrouz Abdelkader[2]

[1] Research unit in Renewable energies in Saharan Medium URERMS, Renewable Energies Development Center, CDER, 01000, Adrar, Algeria
[2] Department of Hydrocarbons and Renewable Energies,Laboratory of Sustainable Development and Computer Sciences (L.D.D.I), Ahmed Draia University - Adrar (Algeria),

*Corresponding author; Email: tahrimoulayahmed@gmail.com

Article Info

Article history:

Received 28/01/2023
Revised 03/03/2023
Accepted 25/04/2023

Keywords:

Frying oil
Extraction
Transesterification
Fuel
Biodiesel

ABSTRACT

Over the past three decades, biodiesel has experienced remarkable development. This fuel, obtained from vegetable oils or animal fat, has the advantage of being renewable, less polluting, and reduces the energy dependence of oil-importing countries.In this article, we are interested in the production of a biofuel based on non-food used frying oil. The physico-chemical characteristics for Oleor vegetable oil are found to comply with established standards. After subjecting the oil to repeated frying using potatoes, followed by a physico-chemical evaluation, the results obtained showed the thermo-oxidative alteration of this oil, confirmed by the evolution of the physico-chemical indices. chemicals during frying.

At the end, this used oil is recovered as fuel (biodiesel). The production of biodiesel is obtained by the transesterification reaction, with a conversion rate of 85%. The physico-chemical properties determined are very interesting and close to those of commercial diesel.

I. Introduction

The production of biofuels such as biodiesel has attracted considerable attention as a less polluting renewable energy source, which can greatly contribute to reducing our dependence on fossil fuels [1] [2]. So far, biofuels are produced from food crops, such as sunflower, soybeans, rapeseed, wheat, beets, sugar cane and other food products. This causes competition with their food use [3].

As a result, food prices have reached their highest levels since the 1970s [4]. Which threatens the food security of the poor populations of the planet. Therefore, it is wise to find other sources of biofuel that do not present any danger to food safety [5].

Among the new sources of biofuels, degraded frying oil presents an interesting substrate, because it is non-food and can cause human toxicity and its treatment as waste is expensive [6].

For this, its recovery as a biofuel is the best choice which falls within the framework of waste treatment and sustainable development [7].

Frying is a popular cooking method around the world. However, the oils used for this type of cooking very often contain a large amount of unsaturated fatty acids[8]. Thus, during prolonged use of frying oil, various degradation reactions occur. Among these, oxidation, polymerization, hydrolyses and isomerization. These reactions have effects on the functional, nutritional and organoleptic characteristics of the oil, and can result in the formation of compounds that have harmful effects on health [9].

This study is based on the determination of some physico-chemical characteristics of an Oléor edible oil, as well as the evolution of these characteristics after several fryings. A second study in this work focuses on the recovery of this oil after its degradation for the production of biodiesel.

This product has a high value and contributes effectively to the protection of the local ecosystem; in other words, preservation of the environment which is our main objective.

II. Research Method

This work focused on a vegetable oil with five different stages of frying uses.

1- Virgin: Do not undergo any cooking method (frying) is a raw vegetable oil.

2- One time use: It is used only once for frying.

3-Three times of use: The frying process has gone through three uses of this commodity.

4-Five times of use: This oil has 5 times of use.

5-Ten times of use: This oil has 10 times of use.

II.1 Characterization of frying oil

The characterization of the oil focused on the determination of the following parameters:

The acid index, which was determined cold, according to the EEC method n°2568 (1991), and expressed in % of oleic acid [9].

The saponification index, The method used is standardized (NF T 60-206, 1990). The saponification index is the quantity of potash necessary (number of milligrams of potassium hydroxide) to transform the free or esterified fatty acids present in an oil into soaps. It depends on the average length of the fatty chains of the acids that make it up. It is all the greater as the chains are shorter.

The refractive index, It is the ratio between the speed of light in vacuum, at a defined wavelength, to the speed of propagation in the substance. The wavelength chosen is that of the average of the D lines of sodium. The measurements are carried out using an ABBE refractometer, at a temperature of 20° C., the method followed is that described in standard AFNOR T 60-212.

The viscosity, Viscosity is determined under European standard ISO 3104 October 1994. It characterizes the resistance to oil flow. The flow time by gravity of an oil fraction is measured through a capillary viscometer contained in a bath at a given temperature.

The density, was determined according to the AFNOR NF T 60-214 standard at a temperature of 40°C by weighing volumes of 250µl of oil using a precision balance (10 - 4 g) p.

The peroxide index, was determined according to EEC standards n°2568 (1991) and is expressed in milliequivalents of active oxygen per kilogram of fat [10].

II.2 biodiesel synthesis

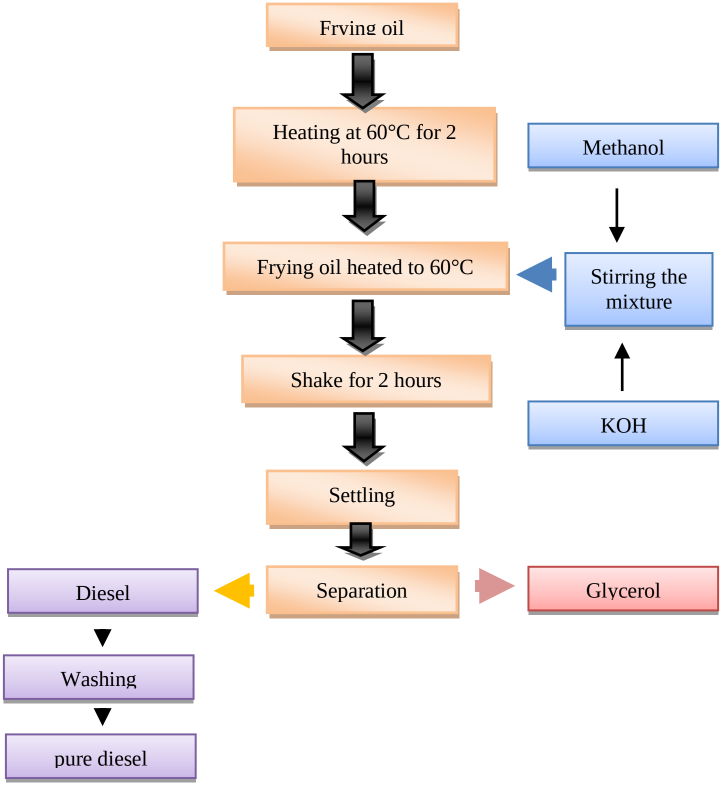

Figure1. Biodiesel production diagram.

Figure 2. Ester rinse.

Figure 3.Biodiesel produced from used frying oil.

III. Results and Discussions

III.1 Monitoring of the Physico-Chemical Quality of Oil

Tabe 1. Monitoring of the Physico-Chemical Quality of Oil

Characterization	Virgin	One time use	Three times of use	Five times of use	Ten times of use
Density	0.908	0.917	0,919	0,921	0,990
Saponification index(mg/KOHg)	196.01	210.23	216.42	230.60	268.22
Refractive index	1.474	1,468	1,472	1,476	1,478
Viscosity	25.22	33.489	35.6612	42.554	47.207
Acid index	0,32	0,36	0,51	0,72	0.92
Rate of polar compounds	21,67	28,33	29,83	33,83	38,67

A significant increase in density, and records that the 5th frying up to the 10th frying of Oléor oils are values higher than the standards (0.907-0.931) successively.

The saponification index values for the 5th and 10th oil frying are higher than the Food Codex standard and increase with repeat frying.

The measured refractive index of virgin oil is IR = 1.474. This value is in agreement with other [11], which give a value for the refractive index of oil IR = 1.473. By way of comparison, the refractive indices of Oléor virgin oil and of the various fried foods are given.

Show a significant increase in viscosity for oil according to the number of fryings.

The acid number of Oléor oil is 0.32. This result is acceptable according to the Food Codex which says that the AI must be less than 0.6 mg KOH / g, The acid index values for the 5th, and 10th oil frying are higher than the Food Codex standard.

According to (DGCERF; 2012) [12] international standards for the rate of polar compounds must not exceed 25%.

Table 09 and figure 20 represent the results of the rate of polar compounds in used edible oils. In this parameter, the only samples that complied with the standards are virgin oils with values of 21.67%.

After the cooking (frying) of the oils with the food, and the reuse of frying operation at 10th frying, we can see in general in the figure a significant increase. Are exceeded the threshold of 25% (28.33%, 29.83%, 33.83%, 36.5%, 38.67% respectively)

III-2 Characterization of the resulting biodiesel

The comparison of the results obtained with those of the scientific literature is an important operation because it consists in being framed in the standards of the research. As a result, during the manufacture of our biodiesel, we were confronted with certain remarkable points, namely the reaction time and the phase of the separation between the biodiesel and the water.

III-2.1 The yield of biodiesel production

According to HUAYANG et.al. [13], and other papers, the reaction yield is calculated by the following formula:

Biodiesel yield = (mass of biodiesel/mass of oil)x100

Biodiesel obtained by the transesterification reaction, (which consists of adding methanol to frying oil) with a conversion rate of 85.01%. Our results are superior compared to other results which find a conversion efficiency of 89% (Benard. A 2017) [14], and 70% (Rhiad A, al. 2013) [15].

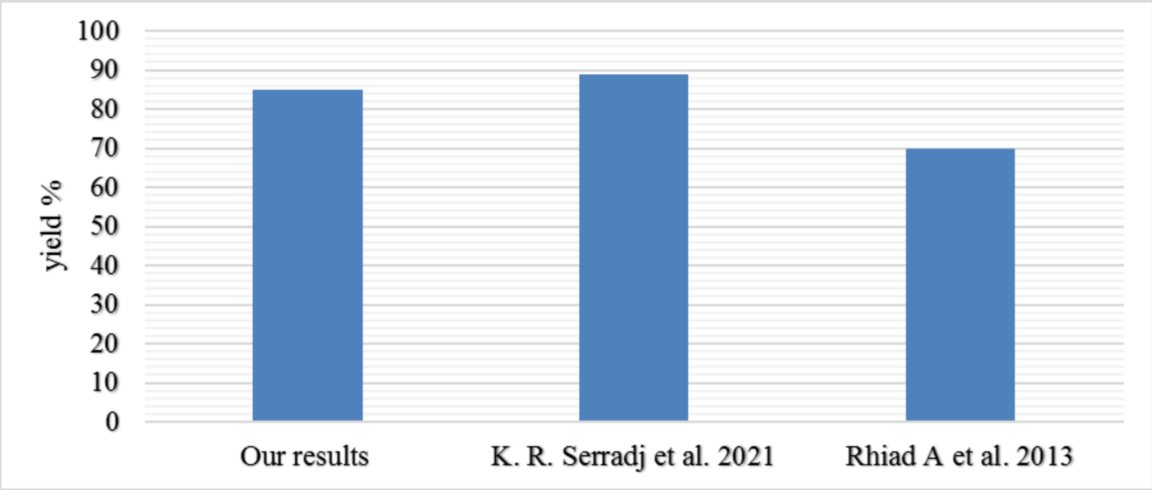

Figure 4. Comparison of our performance results with other studies.

III-2.2 The density

The density was measured according to the method (ASTM D4052) using a DNA4500 type densimeter. After transesterification, the density of waste oil 0.9081 decreases to 0.871 in biodiesel. The latter remains higher than the densities of 0.780 kerosene; light diesel 0.830 and heavy diesel 0.860; but it is very close to that of FCC diesel which has a density of 0.90. The density of commercial diesel is 0.810-0.860 (Benali, B, 2015) [16].

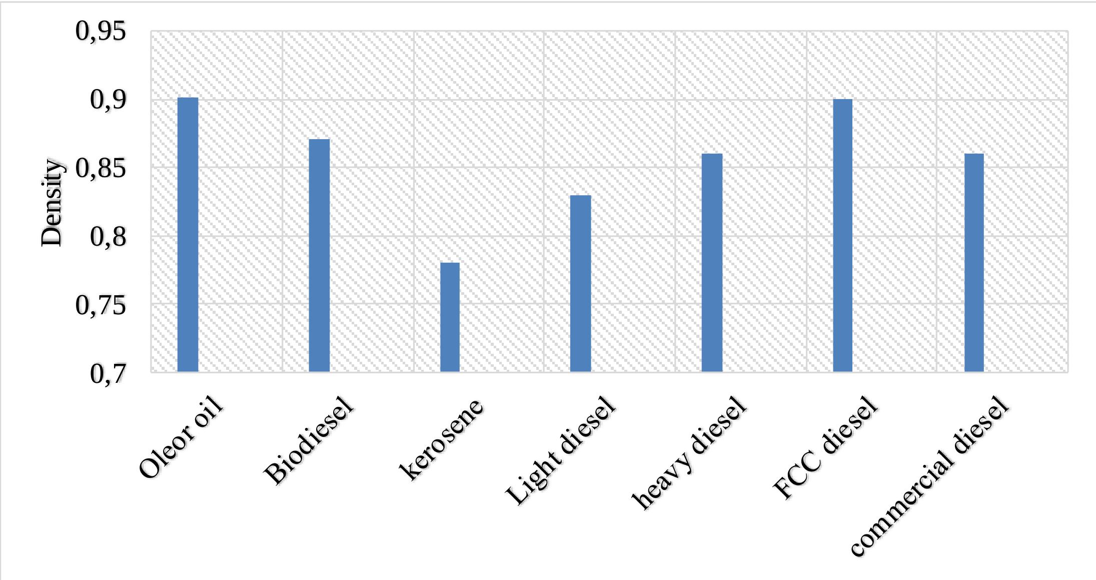

Figure 5. Comparison of our biodiesel density results with other energy products.

III-2.3 The viscosity

The viscosity of cooking oil biodiesel was measured according to the method (ASTM D445); at 40°C.

The viscosity of biodiesel is 5.325 mm2/s at a value very close to that of diesel which is around 6 mm2/s at 40°C. Viscosity is an important characteristic of fuels, it is highly dependent on temperature and has a direct influence on the operation of the injection system, especially at low temperatures.

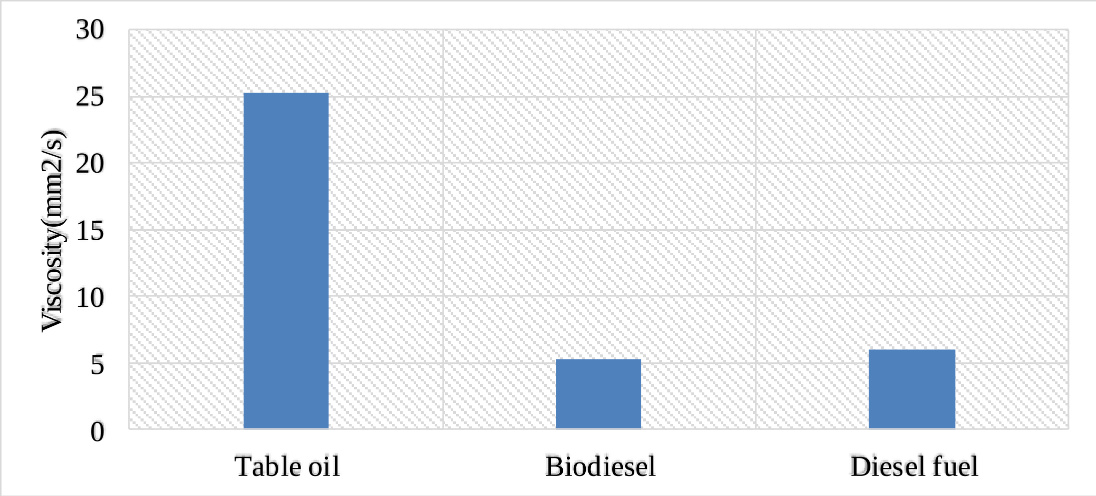

Figure 6. Comparison of viscosity of biodiesel with other energy product.

IV. Conclusion

The physical and chemical properties of biodiesel produced from used frying oil are interesting. The viscosity of biodiesel is 5.325 mm2/s, a value very close to that of diesel which is around 6 mm2/s at 40°C (kerosene 7.37% - light diesel 37.82% - heavy diesel 27.56% - diesel FCC27. 24%). for the density it is 0.871 in biodiesel. The latter is very close to the density of FCC diesel and commercial diesel whose values are 0.90 and 0.810-0.860 respectively, according to SORALCHIN, 2015).

The results obtained during our work are very satisfactory and encourage the recovery of this type of waste as biofuel. A pilot-scale study is needed to better optimize the conversion process and facilitate industrial-scale production to recover used oils and produce biodiesel at the local and national level.

References

[1] Tahri, A., Kalloum S.(2021). Energy Recovery by Production of Electricity from Anaerobic Digestion of Organic Waste in the Saharan Environment. *Algerian Journal of Renewable Energy and Sustainable Development* 3 (1), pp.63-73.

[2] Laribi S, Mammar K, Arama F.Z, Ghaitaoui T. Analyze of Impedance for Water Management in Proton Exchange Membrane Fue Fells Using Neural Networks Methodology. *Algerian Journal of Renewable Energy and Sustainable Development, 2019, 1(1),69-78..*

[3] Campbell, E.J, (1983). Sunflower Oil, *J. Am. Oil Chem. Soc*, (60) pp.387-392.

[4] I.M. Atadashi. (2011). Biodiesel separation and purification: A review, Renewable Energy (36).pp 437-443.

[5] U. Rashid. (2008). Moringa oleifera oil: A possible source of biodiesel, Bioresource Technology (99).pp 8175–8179

[6] L.M. Das. (2009). Long-term storage stability of biodiesel produced from Karanja oil, Fuel (88) pp.2315–2318

[7] Mohamed A. Moneim, Ahmed M.A.(2018). Direct conversion of an agricultural solid waste to hydrocarbon gases via the pyrolysis technique. Egyptian Journal of Petroleum, Volume 27, Issue 4, , pp. 991-995.

[8] A. Amin, A. Gadallah, A.K. El Morsi, N.N. El-Ibiari, G.I.Experimental and empirical study of diesel and castor biodiesel blending effect, on kinematic viscosity, density and calorific value, Egyptian Journal of Petroleum, Volume 25, Issue 4, 2016, pp. 509-514

[9] Règlementation (CEE) de la commission n° 2568/91 du 11 juillet 1991, relatif aux caractéristiques des huiles d'olive et des huiles de grignons d'olive, ainsi qu'aux méthodes d'analyses y afférentes. Journal Officiel des CE n° L 248 du 5 septembre 1991.

[10] C.-J. Shieh et al. (2003). Optimization of lipase-catalyzed biodiesel by response surface methodologyBioresource Technology (88).pp103–106

[11] Y.C. Sharma, B. Singh. (2008).Development of biodiesel from karanja, a tree found in rural IndiaFuel (87).pp 1740–1742

[12] DGCERF.(2012)Guide de contrôle des huiles de friture.

[13] Hua, Y, Zhou, S, Huang, Y, Liu, X, Ling, H, Zhou, X, Zhang, C & Yang, S (2020), 'Sustainable value chain of retired lithium-ion batteries for electric vehicles', Journal of Power Sources, vol. 478, 228753. https://dx.doi.org/10.1016/j.jpowsour.2020.228753

[14] Udeh, J., (2017). Biodiesel Production from Waste Vegetable Oil (Sunflower) Obtained from Fried Chicken and Plantain. *Pet Environ Biotechnol, (8)2 D0I: 10.4172/2157-7463.1000321*

[15] Rhiad, A., A, Liazid., Mohand T., (2013). Valorisation énergétique de l'huile de ricin pour la production du biodiesel dans les zones arides et semi-arides en Algérie JITH 2013 Maroc.

[16] Benali, B., (2015). Master en chimie de l'environnement. *SORALCHIN Society Raffling Algerian-Chinese Ed Paris., pp. 115-139.*