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Research Article

Monitoring of the Physico-Chemical Quality of a Frying Oil and its Valorization as Biofuel (Biodiesel)

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Abstract – The production of biofuels such as biodiesel has attracted considerable attention as a cleaner source of renewable energy, which can greatly contribute to reducing our dependence on fossil fuels.

In this study, we were interested in the production of a biofuel based on non-food used frying oil, and 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 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.

Keywords – Cooking Oïl; Transesterfication, Biodiesel

I. Introduction

Due to the problem of greenhouse gas emissions and the upcoming shortage of hydrocarbons, many countries are looking for new energy sources as a solution. Biofuels are produced so far from food crops, such as sunflower, soybeans, rapeseed, wheat, beets, sugar cane and other food products

Biodiesel is a mixture of fatty acid esters obtained from vegetable oils or animal fats by transesterification in the presence of basic homogeneous catalysts such as soda or potash

As a result, food prices have experienced their highest levels since the 1970s (R. Alloune Et Al. 2012), which represents a danger for the food security of the poor populations of the planet. Therefore, it is wise to enhance the potential of non-food culture in Algeria, with the aim of supporting agriculture and promoting social inclusion and rural development, and which will be part of a concept of sustainable development.

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. Materials and Method

A. Plant material

1. **COOKING OIL:** The oil used in this study is a vegetable oil, more precisely the brand Oléo 5L

Figure. 1 – Oléo Oil

We chose the potato plant for this study based on the following criteria:

- The availability of the plant (it can be grown anywhere in the world);
- The potato is a food plant most used in frying.

Figure. 2– Potato

B. Frying Steps

1st step

Soak the potato slices in a basin of water for about 2 minutes, then let them dry. Put a precise volume of new oil in a frying pan and put on medium heat. This is tricky: put French fries in the pan before the oil heats up. Watch the chunks of french fries and toss them around in the pan until the oil begins to brown.

- Put the slices of french fries in the pan before the oil starts to get too hot (180 0C). The oil can burn and start to make an unpleasant fire.
- Remove the French fries from the pan. Repeat frying 10 times in Oléor oil.

2nd step

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

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

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

Three times of use: The frying process went through three uses of this commodity. Five times of use: This oil has 5 times of use.

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

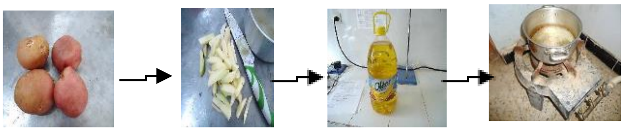

Figure 3: Frying steps

C. Biodiesel Synthesis Protocol

The synthesis of biodiesel involves the following four steps

Reaction

Using a digital scale, we weighed 150g of frying oil in a 250ml Erlenmeyer flask.

Subsequently, we heated in a water bath under a temperature set at 60°C for a period of 2 hours. After weighing 1.5 g of caustic soda and 42 g of methanol using the digital balance, we mixed the reagents in a 100ml Erlenmeyer flask. Then we stirred this mixture until the complete dissolution of the soda using a magnetic stirrer.

mixing of reagents

After two hours, we poured the mixture (methanol + sodium hydroxide) into the Erlenmeyer flask containing the frying oil and we again stirred the mixture obtained with a magnetic stirrer for 2 hours.

Separation of products

After a day of rest, we observe a separation of the mixture contained in the separatory funnel. This is proof that the separation generated two new products: glycerol and biodiesel. Since glycerin is denser than biodiesel, it ends up at the bottom of the separatory funnel and will be collected from the bottom of the funnel.

Washing of the obtained ester

The resulting ester must be washed to remove excess alcohol and catalyst. The biodiesel is placed in a separatory funnel and the water is slowly poured in for rinsing (about 100ml). Then we recover the biodiesel. The alcohol and the residual catalyst dissolve in the aqueous phase.

Distillation

After washing the biodiesel, it is distilled to remove the excess water and methanol in the biodiesel and obtain pure biodiesel.

D. Characterization of frying oil and biodiesel produced.

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

- the acid index (AFNOR T60 204),
- the saponification index (AFNOR T60 206),

refractive index (AFNOR T 60 212), viscosity (ISO 3104 October 1994.),

the density (AFNOR T 60 214) and the peroxy index of ,

- the rate of polar compound (article 30 of law 09-03 of February 25, 2009 on consumer protection and fraud prevention)

III. RESULTS

A. Results of the physicochemical analyzes of different oil fryings

Density

Oil density is measured at a temperature of 20°C. Every precaution has been taken to accurately measure the density at this temperature.

The density found for our rod oil is 0.908.

Table 1: the density of the different frying oléor oil

Oil	Density
Oléor verge	0.908
1st frying	0.917
3rd frying	0,919
5th fries	0,921
6th frying	0,9490
10th fry	0,990

Index of refraction

Table 2: refraction indices of different frying

Oil	index of réfraction
Oléor verge	1,474
1st frying	1,468
3rd frying	1,472
5th fries	1,476
6th frying	1,475
10th fry	1,478

Viscosity

Table 3: viscosity of different frying oleor oil

Oil	Viscosity
Oléor verge	25.22
1st frying	33.489
3rd frying	35.6612
5th fries	42.554
6th frying	43.418
10th fry	47.207

Rate of polar compounds

Polar compounds were obtained from the oxidation and thermal reaction of oil during frying. Hence, more polar compounds in the oil.

Table 4: results for the levels of polar compounds of the various frying oil

Oil	polar compounds
Oléor verge	21,67
1st frying	28,33
3rd frying	29,83
5th fries	33,83
6th frying	36,5
10th fry	38,67

Acid value

The acid index is the mass of potash (in %) necessary to neutralize the free fatty acids of the fatty substance. It indicates the degree of alteration of the esters (mainly triglycerides) present in the fatty substance.

Table 5: acid index results of various frying oil

Oil	Acid value
Oléor verge	0,32
1st frying	0,36
3rd frying	0,51
5th fries	0,72
6th frying	0,81
10th fry	0.92

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.

Table 11: results of the saponıficatıon ındex of dıfferent fryıng oıl

Oil	Saponification index KOH g
Oléor verge	196.01
1st frying	210.23
3rd frying	216.42
5th fries	230.60
6th frying	244.35
10th fry	268.22

Biodiesel yield and its characteristic

According to HUAYANG et.al 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% (K. R. Serradj et al. 2021) and 70% (Rhiad A, al. 2013)

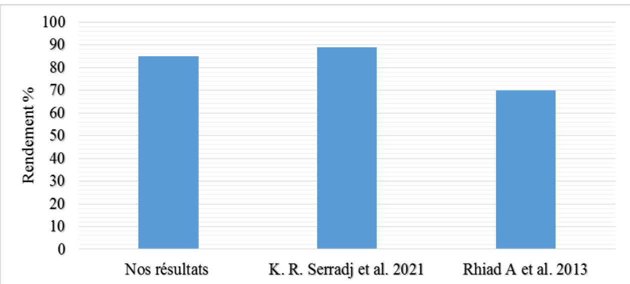

Fig. 4 Comparison of our performance results with other studies

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 (SORALCHIN, 2015).

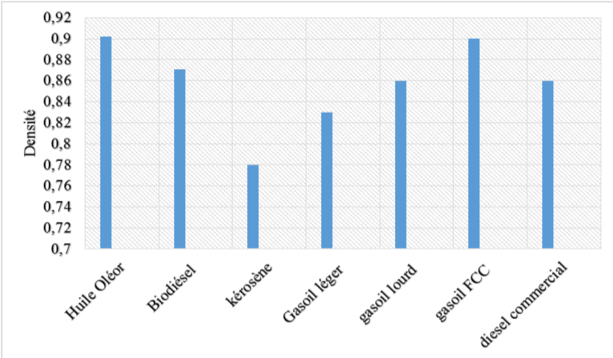

Fig. 5 Comparison of our biodiesel density results with other energy products

Viscosity

The viscosity of cooking oil biodiesel was measured according to the method (ASTM D445); in the URERMS Adrar laboratory 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 depends strongly on the temperature and directly affects the operation of the injection system, especially at low temperatures.

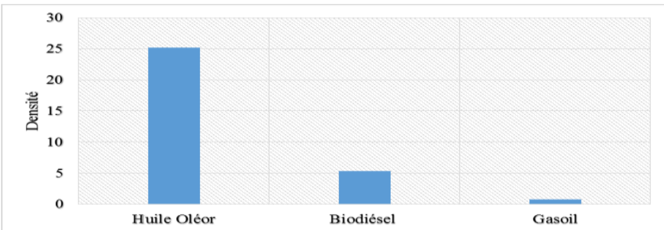

Fig. 6 Comparison of viscosity of biodiesel with other energy product

IV. Conclusion

The aim of the work carried out is to study the quality of a frying oil (Oléor) and the evaluation of the physico-chemical parameters during its degradation, and its valorization as biofuels (biodiesel).

All the results obtained during the monitoring of the physico-chemical parameters of the oil after 10 frying cycles show us that:

- In terms of physical characteristics (density, viscosity, refractive index), there is a difference with the evaluation of these parameters during frying, which indicates that the oils have lost their purity.
- The determination and monitoring of the chemical indices of the oil studied after each frying show an evolution of the acid index from 0.36 to 0.92 in (%) of KOH and the saponification index up to a value of 268 .22 mg/KOH g, l,
- We find that after 10 potato frying cycles, the oil tested showed a degradation that exceeds the regulatory criteria.
- During the frying process, several degradations occur at the level of fatty acids (polar compound), this is due to the temperature used, the foods that are fried there as well as the presence of oxygen in the oil.
- following (reaction temperature 60°C, alcohol/oil ratio 42/150 v/v).
- 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.

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