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Research Article

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Study of manufacturing biodiesel from waste animal fats (chicken) in Morocco

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ABSTRACT

The objective of this work is to propose a new process to make biodiesel from chicken waste by the transesterification process. The experimental part presents a method to recover fat wastes from the chicken slaughterhouse process and extract the anhydrous fat from it. The final product obtained by transesterification was biodiesel fuel, which can be used as an alternative fuel. The glycerin obtained as byproduct must be further processed to compete in quality with synthetic glycerol. Various tests were conducted to maximize the transesterification reaction. Thus with one kilogram of chicken wastes (heads, stomachs ...) we recovered 300g of anhydrous fats. The transesterification in the presence of 1.1% KOH, with a catalyzed reaction at 60°C, gives a yield of 98% in biodiesel. The comparison of our results with literature showed that the manufacture of biodiesel from chicken waste gave similar results as from pig and beef fats.

Keywords: waste, grease, oil, biodiesel, catalyst, transesterification, bioethanol.

INTRODUCTION

Energy demand will still increase considerably in the upcoming years due to population growth and gradual rise in living standards, especially in developing countries. Thus, needs should double by 2050. To satisfy this demand, the energy sources will become more complementary than competitive. All energy options must be kept open to provide the most appropriate responses, at both environmental and economical point of view.

Hydrocarbons will play a major role in the future, particularly in the transport and petrochemical sectors. They will remain difficult to substitute in the short and medium terms. Based on these conclusions, the technological solutions that will ensure the future energy needs and mobility should be developed by considering the finite nature of hydrocarbon resources and the problem of climate change. Thus, as a sustainable development perspective, it is necessary to ensure a long term energy supply, while protecting the local and global environment (reduce negative environmental impacts, i.e. greenhouse gas emissions).

All these factors make it necessary to research and develop sustainable renewable energy sources. Biomass sources, especially animal fats provided by slaughter waste, have attracted much attention as an alternative energy source. They are renewable, non-toxic and can be produced locally from agricultural resources and slaughterhouses. Furthermore, they emit less harmful emissions in the environment.

The development of food industrial activities (IAA) causes residual waste that has a negative impact on the receiving environment [3]. This second category of wastes includes food industry organic wastes, which are:

- Animal wastes originated from meat, fish and milk,
- Plant wastes from the wine industry (marc, lies ...) and from the fruit, vegetables, grains and oilseeds processing,
- Feedstock vegetable or animal wastes (slaughterhouse waste),
- Fallen developed products or substandard products (pasta, cheese ...),
- Sludges from effluent treatment.

These inorganic and organic wastes are in most cases dumped in the landfill. The main problem with these wastes is to get rid of without causing additional nuisance. Thus, they need to be treated and if possible valorized. The selected treatments depend on waste categories, produced quantities by types, advantages and disadvantages of each treatment and its cost. Moroccan agriculture has experienced over the past twenty-five years a boom. A waste reuse in accordance with regulations *(Law No. 28.00 on waste management and disposal "Dahir No. 1-06-153 of 30 Shawwal 1427 (22 November 2006), BO No. 5480 of 7 December 2006")* minimized their risks and impacts: It is the synthesis of **BIOFUELS** from poultry and fish slaughter waste fats.

EXPERIMENTAL SECTION

2.1 Transesterification

The transesterification [1] of triglycerides is not a new process. It dates from 1853 when Duffy and Patrick led this reaction many years before the first diesel engine became functional [4].

This reaction has been the subject of intensive research due the various applications of its products. It includes synthesis of polyesters for the polymer industry [5], synthesis of intermediates for the pharmaceutical industry [6], hardening of resins for the paint industry and production of biodiesel as an alternative diesel fuel.

Transesterification or alcoholysis is an exchange process of an alcohol function R_1 with an ester one R_2 [7]. This process has been widely used to reduce the high viscosity of triglycerides. The transesterification reaction is represented by the general equation in Fig1 [8].

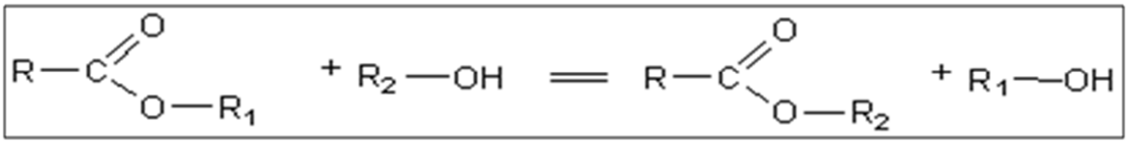

Fig1: General equation of transesterification

When methanol is used the process is said methanolysis. The same think for ethanol. The methanolysis, ethanolysis or triglyceride are shown in Fig2.

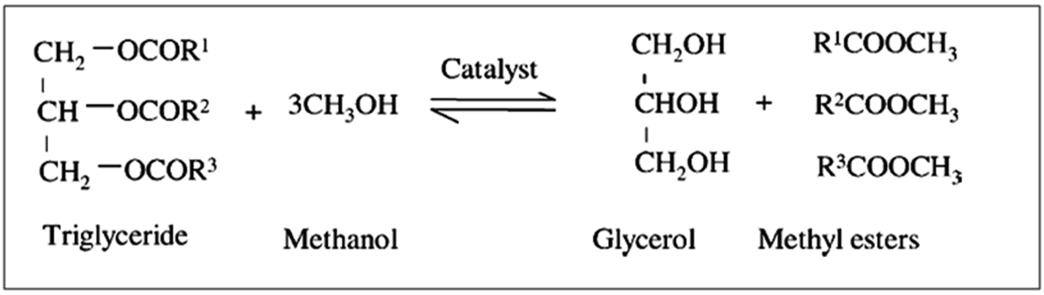

Fig2: General equation of transesterification of triglycerides

2.2 Materiel

The material used during this work is the raw chicken fat wastes. The different products used in order to produce biodiesel are summarized in table 1 with their properties.

Our experiments were conducted in order to evaluate the influence of the various parameters on the reaction of transesterification, namely the alcohol quality, the catalyst amount, the reaction temperature, and the reaction stirring time. Thus, we tried different set of conditions to know those who influence the conversion of fats into alkyl esters. We will present the different conditions used for each step of our process.

Table 1. Products used in biodiesel production and their properties

Product	Utilization	Molar mass g/mol	Density
Dichloromethane CH_2Cl_2	Reagent	84,93	1.325
Diesel	Reagent	_	0,82 à 0,86
Phenolphthalein	Colored indicator	318,32	1.299
Na_2SO_4	Dryer	142.04	2.68
Methanol CH_3OH	Reagent Alcohol	32.041	0,79664
Ethanol C_2H_5OH	Reagent Alcohol	46.068	0.789
Caustic soda NaOH	Catalyst	39,997	2.1
Caustic potash KOH	Catalyst	56.105	2.044
HCl (0.5N)	Acide	36.46	1.186
Isopropyl	Alcohol	60,095	0.785

RESULTS

3.1. Chicken fat oil extraction

For the extraction of oil we used two solvents:

- The dichloromethane, removed by evaporation.
- The diesel oil used as solvent to extract oil from fats. The mixture (oil + diesel oil) will subsequently be used as reagent for transesterification.

Table 2. **Extraction yield of dried fat depending on the used reagent**

	Extraction with CH_2Cl_2 Case A	**Extraction with diesel oil Case B**
	1450g of chicken wastes → 690.14g of raw fat wastes + water → 407g of pure and dried extracted fats	1500g of chicken wastes → 714.47g of raw fat wastes + water → 297.75g of pure and dried extracted fats
Yield	**28.09 %**	**19.85%**

The Yield of the dried extracted fats reached 28% when dichloromethane was used as reagent, which is better than that extracted with diesel (20%). Furthermore, the use of diesel oil can cause impurity problems (sulfur, aromatics, unsaturated ...). The latter give rise to undesirable products during the transesterification reaction.

3.2. Transesterification reaction:

- **Methanolysis :**

The preparation of methyl esters took into consideration the different conditions of the transesterification reaction. The table below shows the various conditions made during the process of alcoholysis and the conversion rate.

Where, Conversion rate = (Amount of produced ester / Initial oil quantity) × 100.200-220 ml of alcohol reagents for 1 liter of oil was used.

In both cases of methanolysis (A and B), we obtained different results due to changes in the parameters of the reaction. A good conversion of ester, which is approximately 96%, was obtained in both cases.

Table 3. Operating conditions of methanolysis (Case A)

Test N°		**Parameters**				**Conversion to biodiesel**
		Catalyst	**Temperature**	**Stirring**	**Reaction time**	
A	**1**	0,9	30°C	Ave-Max	45min	38%
	2	0,95	30°C	Ave-Max	45min	65%
	3	1	30°C	Ave-Max	45min	86%
	4	1,1	30°C	Ave -Max	45min	90%
	5	1,2	30°C	Ave -Max	45min	74%
	6	1,4	30°C	Ave -Max	45min	49%
	7	1.7%	30°C	Ave -Max	45min	Excess of catalyst Formation of soap
	8	1%	35°C	Ave -Max	45min	94%
	9	1%	40°C	Ave -Max	45min	95%
	10	1%	45°C	Ave -Max	45min	96%
	11	1%	50°C	Ave -Max	45min	96%
	12	1%	60°C	Ave -Max	45min	96%

** Ave = Average*

In fig.3 display the results obtained with the fat oil extracted with dichloromethane (case A).

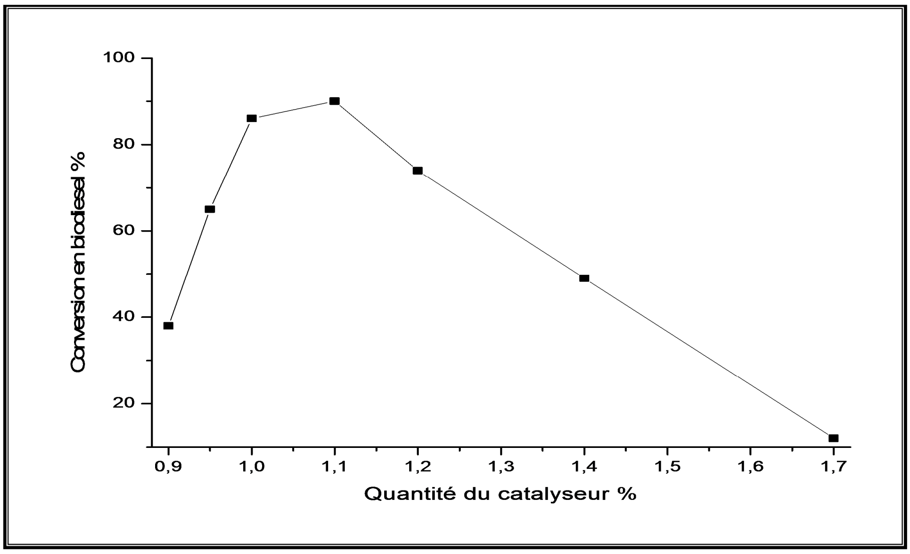

Fig3: The influence of amount of catalyst on the conversion to biodiesel

The change in conversion degree with amount of catalyst at fixed temperature (30°C) presents three important domains. The first presents a linear increase of conversion up to 86% with 1% of catalyst. In the second, where the amount of catalyst is comprised between 1 - 1.1%, there is a stationary variation. This indicates the optimal quantity of catalyst that gives a limit of 90% conversion. Finally, in the third, we have an expected decrease in the conversion due to the excess of catalyst. This excess leads to hydrolysis of the fatty acids contained in the oil, which moves the transesterification reaction towards the formation of soap (saponification).

In a second set of experiments, where we fixed the amount of catalyst at 1%, the variation of conversion with temperature gave the results presented in fig 4.

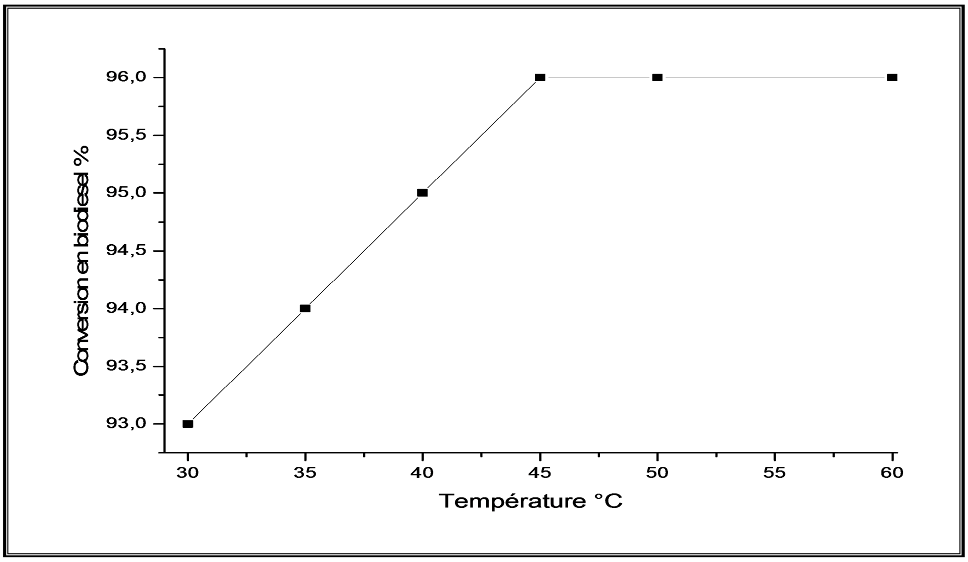

Fig4: Effect of temperature on the conversion to Biodiesel

The variation of conversion rate versus temperature shows a slight increase from 93% to 96% when the reaction temperature varies between 30 and 45°C. Beyond 45°C, the conversion into biodiesel becomes stable.

In the case B (oil + diesel oil), based on the results obtained in case A, the quantity of catalyst was varied between 1 and 1.1% and the temperature between 30 and 60°C.

The variation of the amount of catalyst and temperature with respect to the conversion rate of the mixture (oil + diesel oil) is presented on fig.5.

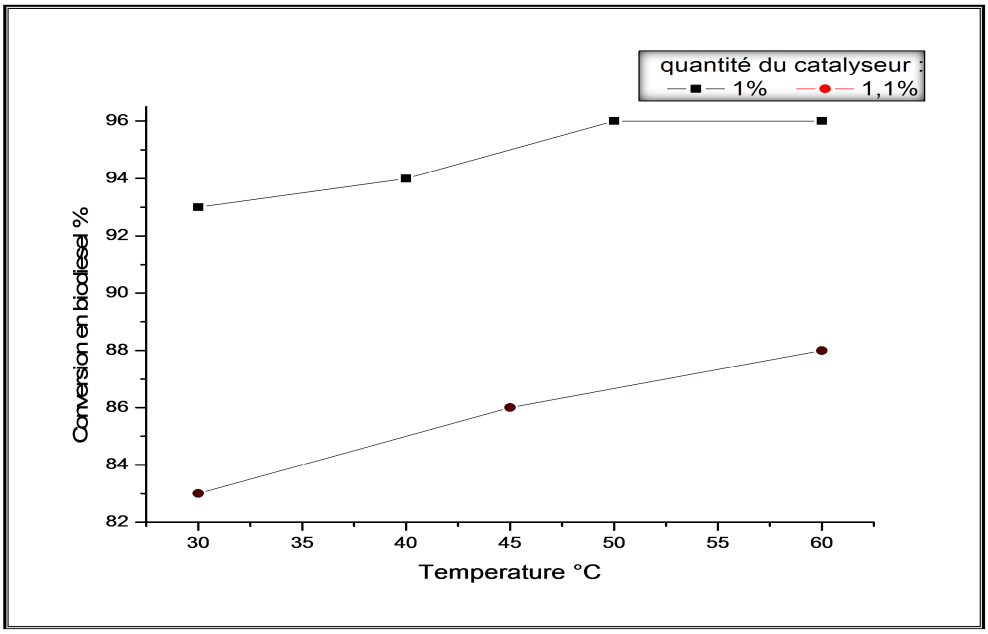

Fig.5: Effect of temperature and amount of catalyst on the conversion to biodiesel

From fig.5, conversion to biodiesel varies mainly between 93% and 96% depending on the temperature when the amount of the catalyst was set at 1%. A maximum rate of about 88% was obtained when the amount of catalyst was 1.1%.

Thus, the synthesis of methyl esters achieved a good yields of 96%. The tests using methanol as reagent helped us to achieve a good conversion of chicken fat oil into biodiesel by following proper conditions of transesterification reaction, which is the decisive step in our process.

3.3 Comparison of our results with literature

The results obtained with the OLVA Technologies methods that produce biodiesel from pig and beef fats [2] were compared to our results of biodiesel obtained from chicken fat. In the table below, which resumes the main properties of each product, we can notice that they are almost similar.

Table 4. Physical properties of biodiesel obtained from different origins

	unity	Pig Biodiesel	Beef Biodiesel	Chicken Biodiesel
Density at 15°C	g/cm^3	0,876	0,87	0,88
Kinematic Viscosity at 40°C	mm^2/s	4,85	4,91	3.8
Flashpoint	°C	128	173	125

CONCLUSION

The work we performed was a valuation of the poultry slaughtering wastes (chicken fat wastes). The results obtained are optimal in terms of biodiesel yield.

The physico-chemical properties of the synthesized biodiesel oil meet well with the literature standards. Thus, it is suitable for use as an alternative fuel against the petroleum diesel, either by filling the tank with 100% of biofuel or by mixing it with oil based petroleum.

The future perspectives points towards further optimization of parameters influencing the process of waste conversion into biofuel, in order to scale up the study to a pilot scale.

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