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Optimization of biodiesel production from waste poultry industry in morocco

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ABSTRACT

In a previous research work we studied the fat trans esterification reaction according to two methods for extracting the fat: with dichloromethane (CH_2Cl_2) quantitatively leading to biodiesel and diesel as a solvent and it does not recover after, leading to biodiesel to 67%. The objective of this work is firstly to optimize these processes proposed using an experimental plan and to compare our results with those of the literature.

Keywords: chicken fat, trans esterification, biodiesel, optimization.

INTRODUCTION

Morocco is a country that promotes sustainable development, knowing that the oil bill is estimated 2014-32 billion dirhams [1] .To Overcome this deficiency, Morocco, trying to diversify the renewable energy resources by introducing solar energy, olein and biomass that are potentially available resources. Morocco produces annually 8,000,000 tons of household and similar waste [2] with 60 % of the fermentable fraction to produce methane gas or solid fuel. These renewable waste found waste from the poultry industry, With a production that rises to 590,000 t with 2014 a growth rate of 7.4 % per year. [3] With an estimated two kilograms per head we can estimate the number of 295 million chickens ' heads. After each shot head produces 500 grams of solid waste is 147,500 t / year with a fat content of 28.1 % [4], the potential is 41 .000t / year.

MATERIALS AND METHODS

The material and reagent that was used in this work is:

1-1 Material

- The 2 liter transesterification reactor fitted with a condenser and a tube containing anhydrous sodium sulphate and equipped with a magnetic stirrer capacity of 1200 revolutions / minute.
- A distillation apparatus ethyl alcohol for controlling the trans esterification reaction.
- A rota steam machine to remove the solvents a fat mill and the usual equipment of the laboratory.

1-2 Reagent

Table 1: Products used in the method and their properties

Product	***Utilisation***
Dichlorométhane CH_2Cl_2	Solvent
Gasoil trade	Solvent
Phénolphtaléine	Colorindicator
Na_2SO_4	Drying
Ethanol C_2H_5OH	Alcool réactif
Caustic soda NaOH	Catalyst
Dry chicken fat	Raw material Purified
HCl (0.5N)	Acid
Isopropyl	Alcohol

The raw material which is the raw chicken fat waste. To prepare biodiesel reagents were used in Table 1.

1-3 Characterization Techniques

To characterize the final product (Biodiesel) we was used gas chromatography coupled to mass spectrometry (GC - MS).

Analysis of our samples was determined in a system of GC-MS HP- 6890 / MSD - 5973. The sample was dissolved in dichloromethane; 4 ml of this solution was injected at 275 ° C in the injection orifice by means of an automatic injector. The column was a 5 % of AT- 5 diphenylpolydimethylsiloxaneAlltech(25m_0.25mm_0.20 mm), and helium was used as carrier gas at a constant pressure 0.28Bar column head . The gradients used were as follows: 60 ° C (1 minute), heating at 6 min to 300 ° C , 10min 300 ° C and allowing 15 minutes between the currents .

Table 2: Comparison of fatty acid composition of chicken oil

Fattyacids	**This work (%)**	**Chia-Wei Lin and al, February 2015 (%) [5]**	**Marulanda and al.(2010) (%) [6]**	**Arnaud and al. (2004) (%) [7]**	**Boey and al. (2011) (%) [8]**	**Lee and foglia, (2000) (%) [9]**	**Arnaud and al.(2006) (%) [10]**
C14: 0 Myristicacid	1	0,96	-	-	0,6	0,7	0,5
C16: 0 Palmiticacid	20	24.57	21.0	24.0	24.7	25.2	24.0
C16: 1 acidpalmétolénique	6	4.83	7.7	5.8	6.3	7.8	5.8
Stearicacid	7	5.80	5.5	5.8	4.5	4.5	5.8
C18: 1 Oleicacid	40	39.81	48.5	38.2	44.1	40.5	38.2
C18: 2 Linoleicacid	19	20.52	17.3	23.8	18.4	18.4	23.8
C18: 3 Linolenicacid	2,2	2.10	traces	1.9	0.2	0.7	1.9

In Table 2, we summarize the fatty acid compositions chicken lipids used in this research and their comparison with the literature [14-19]. Oleic acid Monounsaturated proves the major component of chicken fat (40%). the analysis results are given in function of the equivalent fatty acid content (C < 14 traces , 1% myristic acid C14: 0, 20 % C16 palmitic acid : 0, 6% palmitoleic acid C16: 1, 7 % stearic acid C18 : 0, 40% oleic acid C18: 1 19% linoleic acid , C18: 2 , 2% linolenic acid C18: 3 The remaining C > 20) and are comparable with literature data (Marulanda et al , 2010; Boey et al , 2011; Arnaud et al, 2004 ; Lee and Foglia , 2000; Arnaud et al, 2006). [5-10]

1-4 ***operative Protocol:***

• Extraction of pure fat chickens:

After sorting of the waste, we proceeded to recover the fat contained in the waste. Then washing with water to get rid of any impurity, after the fat is allowed to dry in a desiccator to use P_2O_5.

The second step is the grinding chicken fat. The ground fat is then recovered in order to extract the pure solvent oil. Thereafter, the solvent was removed by evaporation. Fat obtained oil is recovered in a dry material. This is one of the conditions for the trans esterification reaction is not influenced by the presence of traces of water or moisture.

• Trans esterification of the oil fat:

Having obtained the chicken fat oil is carried out reacting the latter with a base catalyst which is in this case sodium hydroxide (NaOH).

For this purpose one has to take into account the factors that influence this reaction to maximize conversion of fats in alkyl fatty acid esters.

We used an excess of alcohol molar ratio of 6: 1 (alcohol: fat). Was varied and the amount of catalyst between 0.9 % and 1.3 % relative to the amount of oil used.The method according to alcoholysis is for the preparation of methyl and ethyl fatty acid esters. The catalyst is dissolved in alcohol with rigorous stirring to ensure formation of sodium ethoxide. The latter is subsequently added to the preheated oil at 45 ° C.

The mixture is stirred for 45 minutes keeping the temperature between 45 and 60 ° C, the time required for proper and complete reaction.

RESULTS AND DISCUSSION

2-1 Conversion rate:

The conversion rate reflects the performance of trans esterification reaction, it is calculated for each experiment by determining the amount of ethanol consumed, taking as a basis the fatty acid oleic acid as a reference, and for kg dry fat is added 6x46 = 276g ethanol and after reaction were removed 400 g of the mixture is distilled to recover the excess alcohol unreacted. Which enables us to know the amount of alcohol that has reacted with the fat .the table below gives the amount of ethanol distilled based on the conversion rate?

Table 2: The amount of ethanol distilled off as a function of conversion rate

Conversion rate (%)	0	38	70	80	86	90	92	94	96	100
Amount of ethanol distilled (g)	94,7	76,70	61,55	56,8	54	52,1	51,15	50,2	49,2	47,35

2-2 Properties Biodiesel according to process A:

Table 3 Comparison of physicochemical properties of the biodiesel produced according to method A with fuel manufactured oil chicken and various combinations of alcohol [5]

Propriété	**Density at 15 ° C Kg / m^3**	**Viscosity at 40 ° C in mm2 / s**	**Flash Point ° C**	**sulfur**	**Water content (ppm)**	**Calorific value MJ / l**	**Cold properties**		
							Flow point °C	**Cloud point ° C**	**Temperature filterability ° C**
our Bio	880	3.8	175	0	0	33.1	-12	-21	-3
Methyl esters from methanol and oil (6:1)	879.6	4.469	170	1.3	1390	-	-	-	-
Ethyl esters from etanol and oil (6:1)	874.7	4.594	186	1.5	1707	-	-	-	-
Mixed methyl/ethyl esters from methanol, ethanol and oil (3:3:1)	879.6	4.822	174	1.2100 max	1852	-	-	-	-
CNS 15072/EN 14214	860-900	3.5-5,0	101 min		500 max	-	-	-	-

• *NB: All measurements were achieved by a certified organization with SNC matching methods [5]*

2-3 Optimization of the biodiesel manufacturing process by two methods:

The main objective is to optimize the intensive and extensive parameters (temperature, reaction time, the stirring speed of the mixture, moisture, fat, the stoichiometry of alcohol, and catalyst concentration) which influence the performance of the trans esterification reaction of the chicken fat.

Previous studies [11-18] have shown that the displacement of the equilibrium towards the formation of the ester biodiesel is done with an excess of alcohol of 1/6 and the humidity must be zero and the reaction time must not exceed 60 minutes with maximum agitation. Under these conditions, to obtain a better yield, it remains to optimize the two parameters of this trans esterification reaction to know the temperature and the catalyst concentration knowing that excessive catalyst causes undesirable saponification reaction.

Following these considerations we opted for a composite design centered in the faces with three centre points for both methods A and B.[20-21]

The approximate model that we propose for process A (used oil is extracted with dichloromethane) and B (oil + gasoil) is:

$$Y(x_1, x_2) = a_0+a_1x_1 +a_2x_2 + a_{11}x_1^2 + a_{22}x_2^2+ a_{12}x_1x_2.$$

The coefficients are calculated using the results of 3 centre points; (0; 0) which correspond to the point (1.0 ; 40 ° C).

The results of experiments were run using the Minitab v15 software. Yields will be scored, Tc (A) for process (A) and Tc (B) for process (B) .Levels are in the following table :

Table 4: design experience levels

	Levels		
	-1	0	+1
Catalyst (C) in%	0.9	1.0	1.1
Temperature (T) in ° C	30	40	50

Results for the process (A)

Table 5: Results for Process (A)

(The reaction mixture consists 67 % of diesel as a solvent) is noted by the return conversion (A)

Catalyst	T°C	Conversion rate *Tc(PA)* Observed	AJUSTEES1 Model	RESIDUELLE1
0,9	30	0,38	0,40658	-0,0265789
1,1	30	0,86	0,87991	-0,0199123
0,9	50	0,90	0,88325	0,0167544
1,1	50	0,92	0,89658	0,0234211
0,9	40	0,70	0,69018	0,0098246
1,1	40	0,93	0,93351	-0,0035088
1,0	30	0,80	0,75351	0,0464912
1,0	50	0,96	1,00018	-0,0401754
1,0	40	0,92	0,92211	-0,0021053
1,0	40	0,90	0,92211	-0,0221053
1,0	40	0,94	0,92211	0,0178947

The analysis was done using the encoded data.
The following table gives the coefficients of the model
$Y(x_1, x_2) = a_0+a_1x_1 +a_2x_2 + a_{11}x_1^2 + a_{22}x_2^2+ a_{12}x_1x_2$.

Table 6: the coefficients of the model

Terms	Coefficients (a_i)	Coef(ErT) σ_{ai} : SD	T Student (observed) Coeff / SD	p-value
Constant	0.92211	0,01868	49,364	0.000
Catalyst ; x1	0.12167	0,01487	8,184	0.000
Temperature ; x2	0.12333	0,01487	8,296	0.000
Catalyst*Catalyst	-0.11026	0,02288	-1,978	0.005
Temperature*Temperature	-0.04526	0,02288	-1,978	0.105
Catalyst*Temperature	-0.11500	0,01821	-6,316	0.001

S = 0,0256973 SomCar-ErrPrév = 0,0251037
S = 0.0256973 = 98.71 % SoR square R square (prev) = 90.17 % R-Squared (adjusted) = 97.42 % MCAR - ErrPrév = 0.0251037
The coefficients were estimated taking into account the three center points.

Coefficients analysis
As the pure erreur variance is unknown in advance, using the t-Student at confidence level 1 - α = 0.95, to calculate the dispersion around coefficients (Δa_i) associated with the effects of the factors and their interactions.

The value of ***t*** at this confidence level 0.975 is given by the Student table, it is: *T(0.975 ; 5) = 2.571.*
Δa_i is given by the following formula.**[20-21].**

$$\Delta ai = t(1- \alpha /2 ; ddl(ai))\times\sigma(ai)$$

Which give ;$\Delta ai = t (0.975 ; 5) \times\sigma ai=2.571\times \sigma ai$ at level confidence à 95% .
If $|ai| > |\Delta ai|$ then the coefficient a_i is statistically non-zero, or significant 95%.
If $|ai| \leq |\Delta ai|$ then the coefficient a_i is statistically zero (not significant) to 95 %.
We give the calculus of different $|\Delta ai|$

	Δa_0	=2.571x 0,01868 = 0.04802628<0.92211 =	a_0	
	Δa_1	=2.571x 0,01487= 0.03823077 <0.12167 =	a_1	
	Δa_2	=2.571x 0,01487= 0.03823077 <0.12333 =	a_2	
	Δa_{11}	=2.571x 0,02288= 0.05882448<0.11026 =	a_{11}	
	Δa_{22}	=2.571x 0,02288= 0.05882448>0.04526 =	a_{22}	
	Δa_{12}	=2.571x 0,01821= 0.04681791<0.11500 =	a_{12}	

The estimated model is:

$$\mathbf{Tc\ (A) =}$$
$$\mathbf{(0{,}92211 \pm 0.04802628) + (0{,}12167 \pm 0.03823)\ x_1 + (0{,}12333 \pm 0{,}03823) x_2}$$
$$\mathbf{- (0{,}11026 \pm 0{,}058824) x_1^2 - 0{,}04526 x_2^2 - (0{,}115 \pm 0.04681) x_1 x_2}$$

The coefficient 0.0452 is not significant in the model.

Table 7: Analysis of variance for process (A)

Source	*Degree of Freedom (DL)*	*sum Square*	*SomCar ajust*	*CM ajust*	*F observed*	*p-value*
Regression	5	**0,278988**	**0,278988**	**0,055798**	**42,08**	**0,000**
Linear	2	**0,180083**	**0,180083**	**0,090042**	**67,91**	**0,000**
square	2	**0,046005**	**0,046005**	**0,023003**	**17,35**	**0,000**
Interaction	1	**0,052900**	**0,052900**	**0,052900**	**39,90**	**0,006**
Residual error	5	**0,006630**	**0,006630**	0,001326		
Inadequate (bias)	3	**0,005830**	**0,005830**	**0,001943**	**4,86**	**0.175**
pure Error	2	**0,000800**	**0,000800**	**0,000400**		
Total	***10***	***0,285618***				

The residual dispersion is 0.00663 and Q_R is of 5 degrees of freedom.
The sum square of pure error $Q_0 = 0.0008$ and is of 2 degrees of freedom.
The residual variance $S_R^2 = Q_R / 5 = 0.001326$, which gives $S_R = 0.0364138$.
The pure error variance $S_0^2 = Q_0 /2 = 0.0004$ so $S_0 = 0.02$.
The residual variance (0 .001326) is greater than the random variance (0.00040).

A bias test (suitability) is needed to whether this difference is significant or not.

A bias test for process (A)
Since the coefficients were estimated based on the three centre points, S_0^2 and S_R^2 are no longer independent, then we have: $Q_R = Q_0 + Q_{biais}$

Where Q_{biais} is the bias of the dispersion. The degrees of freedom are such that: $ddl(Q_R) = ddl(Q_0) + ddl(Q_{biais})$.

Then comparing the variance through the biais variance using the ratio of Fischer - Snedeccor :

$$\mathbf{F = (S_{biais})^2/(S_0)^2}$$

Where F is a Fischer -Snedeccor law ; $\mathbf{F(1-\alpha\ ;\ ddl(Q_{biais}):ddl(Q_0))}$, [20-21].
In our case, $Q_{biais} = 0{,}005830$ et $S_{bias}^2 = Q_{biais} /3 = 0{,}001943$.

The observed Fischer statistic is:

$F_{obs}=(S_{biais})^2/(s_0)^2 = 4{,}86$, et $F(0{,}95\ ;3\ :2) = 19{,}2$ which is biger then F_{obs} .
We conclud that there is no biais and the analysis is correct, the model:

$$\mathbf{Tc\ (A) =}$$
$$\mathbf{(0{,}92211 \pm 0.04802628) + (0{,}12167 \pm 0.03823)\ x_1 + (0{,}12333 \pm 0{,}03823) x_2}$$
$$\mathbf{- (0{,}11026 \pm 0{,}058824) x_1^2 - 0{,}04526 x_2^2 - (0{,}115 \pm 0.04681) x_1 x_2\ .}$$

is acceptable at 95% of confidence level .

Calculation of the regression coefficients estimated for T c (A), using data uncoded units
The change of variables of the formulas is the following
According to the experiment, the variations are monotonic with respect to each variable, the variable change formula is as follows:

$$\mathbf{X= [U - (U_{min} + U_{max})/2\ ]\ (U_{max} - U_{min})/2}$$

Where X is the variable corresponding to the coded experimental variable U.
Vmin is the minimum value corresponding to the level (X = -1) and the maximum value Vmax corresponding to the level (X = 1).
By replacing in the above formula are:

$$Tc(A) = -17.1384 + 27.8693*C + 0.16354*T - 11.0263*C^2 - 0.0004*T^2 - 0.1150*C*T$$

Response optimization:
The desirability function takes into account the limits assigned to each response. It is defined as follows [20-21]. Suppose we have K replies, $Y1, Y_1, \ldots\ldots, Y_K$. For each response Y_i,

Let Yi^m is the value below which the response Yi is unacceptable, and Yi^M the value above which the response Y_i is acceptable.
Desirability di associated Y_i is defined by:

$$\begin{array}{ll} di = 0 & \text{if } Yi \leq Yi^m \\ di = (Yi - Yi^m) / (Yi^M - Yi^m) & \text{if} Yi^m < Yi < Yi^M \\ di = 1 & \text{if } Yi \geq Yi^M \end{array}$$

The composite desirability for all K answers is defined by: $D(M) = [\prod d_i(M)]^{1/K}$
Where M is a point of the experiment field.

Answers to optimize the conversion rate Tc (A):
In our case, we have an individual desirability (K = 1)
We choose $Tc\ (A)^m = 0{,}93$ et $Tc\ (A)^M = 0{,}98$ Which give :

$$\begin{array}{ll} d = 0 & \text{if } Tc\ (A) \leq 0{,}93 \\ d = 20Rdmt(PA) - 18{,}6 & \text{if } 93{,}\ 0 < Tc\ (A) < 0{,}98 \\ d = 1 & \text{if } Tc\ (A) \geq 0{,}98 \end{array}$$

We studied two scenarios :

Scénarion1.

	Objective	*Target*	*Lower*	*Superior*
Tc(A)	Target	***0.98***	***0.93***	***1***

Starting point
Catalyst = 0.95
Temperature = 45 ° C

Local solution
Catalyst = 0.962722 Temperature = 49.6928

Answersprovided
Tc (PA) = 0.980000, with a desirability equal to 1

Scénarion2.

	Objective	*Target*	*Lower*	*Superior*
Tc(A) (%)	Target	***0.98***	***0.93***	***1***

Starting point
Catalyst = 1
Temperature = 45 ° C

Local solution
Catalyst = 1 Temperature = 46,0275

Answers provided
Tc(PA) = 0,980000, with a desirability equal to 1

It can be said that for a yield of around 98% requires a catalyst concentration in the vicinity of 1% and a temperature of 46 ° C.

Conclusion for process (A)

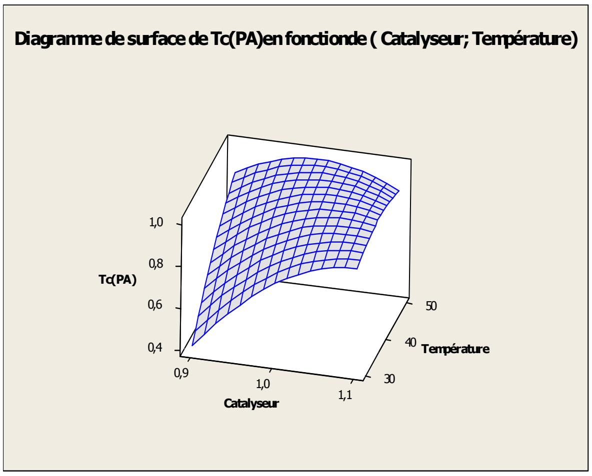
The analysis of the design of experiments allows us to conclude that the model

$$Tc\ (A) = (0{,}92211 \pm 0.04802628) + (0{,}12167 \pm 0.03823)\, x_1 + (0{,}12333 \pm 0{,}03823) x_2 - (0{,}11026 \pm 0{,}058824) x_1^2 - 0{,}04526 x_2^2 - (0{,}115 \pm 0.04681) x_1 x_2$$

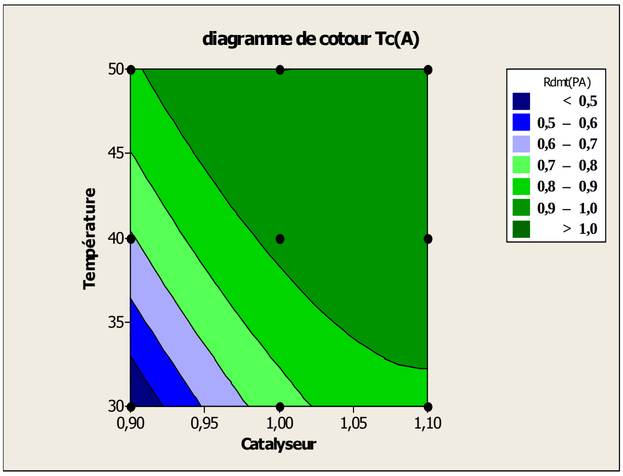
is acceptable with a confidence level of 0.95 %.

The desirability of model analysis leads us to affirm that for a concentration in the vicinity of 1 % and a temperature around 46 ° C, one can have an efficiency of around 98%.

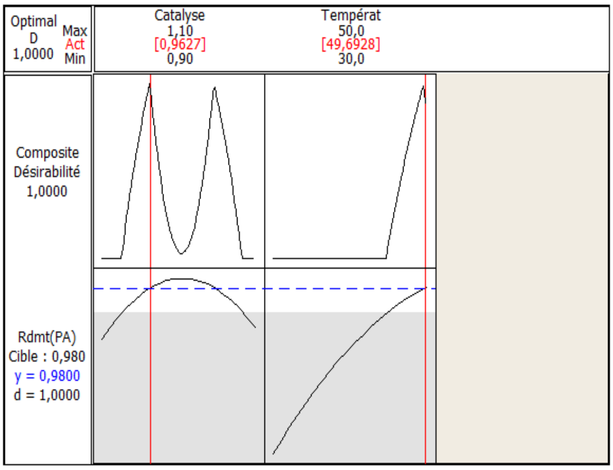
Graphics associated with the conversion rate (PA)



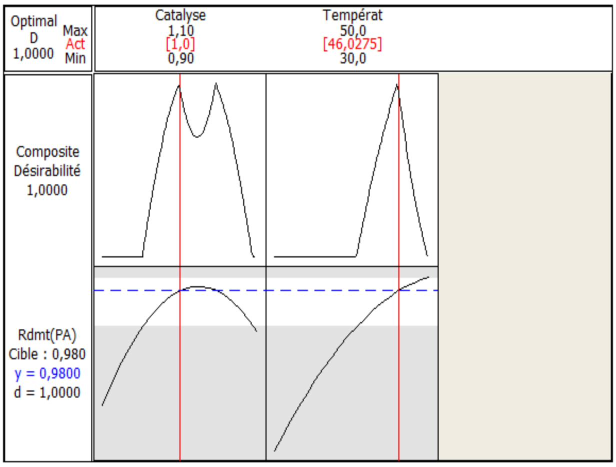
This diagram shows us if the% is fixed in Catalyst; the performance is almost proportional to the change in temperature, where as if the temperature is fixed performance has a concave parabolic curvature.



This contour diagram allows us to see the constraints for each performance.
In our case a catalyst concentration around 1% forces us to experience with a temperature above 40 ° C



This diagram confire although if one wants a 98% yield , it takes a percentage of the vicinity of 0.95% and a temperature of 49 °C. and that to achieve the 98% yield of the conversion of the biodiesel in chicken fat.



This diagram shows that if the temperature is reduced in the vicinity of 46 °C, we must work with 1% of the catalyst and that to achieve the 98% yield of the conversion of the biodiesel in chicken fat.

Results for the process (B)

The reaction mixture consists of 67 % of diesel as a solvent; performance is denoted by Tc (PB)

Table 8: Results for Process (B)

Catalyst	**Temperature (°C)**	**Tc(B) Observed**	**Tc(B) Mmodèle**
0,9	30	0,44	0,438596
1,1	30	0,86	0,841930
0,9	50	0,94	0,938596
1,1	50	0,92	0,901930
0,9	40	0,75	0,752807
1,1	40	0,90	0,936140
1,0	30	0,70	0,719474
1,0	50	0,98	0.999474
1,0	40	0,94	0,923684
1,0	40	0,93	0,923684
1,0	40	0,94	0,923684

The following table shows the model coefficients:

$$Y(x_1, x_2) = a_0 + a_1x_1 + a_2x_2 + a_{11}x_1^2 + a_{22}x_2^2 + a_{12}x_1x_2.$$

These coefficients are estimated taking into account the three center points .

Tbale 9: the coefficient of the process B

Terms	**Coefficients (a_i)**	**Coef(ErT) σ_{ai} : SD**	**T Student (observed) Coeff / SD**	**p-value**
Constant	0,92368	0,01318	70,069	0.000
Catalyst ; x1	0,09167	0,01049	8,738	0.000
Temperature ; x2	0,14000	0,01049	13,345	0.000
Catalyst*Catalyst	-0,07921	0,01615	-4,906	0.004
Temperature*Temperature	-0,06421	0,01615	-3,977	0.011
Catalyst*Temperature	-0,11000	0,01285	-8,561	0.000

S=0,0256973 SomCar-ErrPrév= 0,0251037
R carré = 98,71% R carré (prév)=90,17 % et le R carré (ajust)= 97,42%

All coefficients are significant, and the model is generally acceptable.

Coefficients analysis:
As the random variance is not known in advance, using the Student t confidence level 1 - α = 0.95, to calculate the font of noise associated with the effects of the factors and their interactions.

The value of t at this confidence level 1-.25 = 0.975 is the same as that of Process (PA)

ai		Δ(ai)
0,92368	>	0,03388578
0,09167	>	0,02696979
0,14	>	0,02696979
0,07921	>	0,04152165
0,06421	>	0,04152165
0,11	>	0,03303735

The estimated model is:

$$Tc(PB) =$$
$$(0,93368 \pm 0,034) + (0,9167 \pm 0,027)x1 + (0,14 \pm 0,027)x2 – (0,07921 \pm 0,041)\ x12$$
$$+(0,06421 \pm 0,041)\ x22 – (0,11 \pm 0,033)\ x12$$

Table10:The analysis of variance of the method (B)

Source	***Degree of Freedom (DL)***	***sum Square***	***SomCar ajust***	***CM ajust***	***F observed***	***p-value***
Regression	5	0,252171	0,252171	0,050434	76,37	0,000
Linear	2	0,168017	0,168017	0,084008	127,22	0,000
Square	2	0,035754	0,035754	0,017877	27,07	0,000
Interaction	1	0,048400	0,048400	0,048400	73,29	0,006
residualerror	5	0,003302	0,003302	0,000660		
Inadequate (bias)	3	0,003235	0,003235	0,001078	32,35	0.175
pure error	2	0,000067	0,000067	0,000033		
Total	10	0,255473				

The R square is 98.7 % is the R square adjusted exceeds 97.4% the model is globally acceptable.
Except that the residual variance (0.000660) is much greater than the random variance (0.000033).
This is followed by a test of adequacy.

The residual error Q_R is 0.003302 and is of 5 degrees of freedom.
The pure error and Q_0 is 0.000067 and of 2 degrees of freedom.
The residual variance $S_R^2 = Q_R / 5 = 0.00066$, which gives $S_R = 0.0025698$.
The error pure variance $S_0^2 = Q_0 /2 = S_0 = 0.0000335$ or 0.0057879.

As in the process (A), the coefficients were estimated based on the three center points; S_0^2 and S_R^2 are no longer independent.

In our case, therefore $S_{bias}^2 Q_{biais} = 0.003235 = Q_{biais} / 3 = 0.001078$
The Fischer statistic is observed:
$F_{obs} = (S_{biais})^2 / (s_0) 2 = 0.001078 / 0.00003235 = 33.32$
F (0.95; 3: 2) = 19.2 which largely inferior to F_{obs}.

It is concluded that the statistics have a bias that seems to us to have the effect of diesel solvent factor we have neglected in the process (B) of trans esterification, by cons in the process (A), We had better performance namely that the reaction proceeds in the absence of solvent.

V- Interpretation of results

The results obtained during this process have essentially biodiesel yield with the conversion rate can reach up to 98% under the conditions of 1% in the catalyst and the temperature of 46 ° C.

Our work is the manufacture of biodiesel from chicken fat was compared to that of Chia-Wel et al [5] and has added several very important points which are not considered at several previous studies described in the literature. These points:

- ➢The optimization of our results that have already been published [4].
- ➢Using ethanol instead of methanol knowing that it is toxic and dangerous to health.
- ➢The use of soda that proves cheaper than potassium hydroxide (KOH).
- ➢The fat chicken waste and after grinding, is extracted after crushing or with CH_2Cl_2 is recycled by distillation or with the diesel is allowed to mixed with the final product having a content of the order of 80% which is an advantage for the process (PB).
- ➢The comparison of the composition of different chicken fat never gives the same result, this gives slightly different biodiesels.

CONCLUSION

The work we have carried out a valuation refers to slaughter poultry waste "chicken fat" noted that these are collected from Moroccan butcher.

The results obtained by process (A) are optimal performance standpoint which must be a percentage of 1% in the vicinity of the catalyst and a temperature of around 46 ° C to reach approximately 98% yield.

The synthesized biofuel has physicochemical properties conform to the standards cited in the literature. Therefore, it meets the requirement for use as an alternative fuel of diesel oil is obtained by feeding the tank with 100% of the biofuel obtained according to the method (A) or mixing the diesel for process (B).

Although the method (A) is better than the method (B) of the optimization point of view, but it remains acceptable, in particular on the technical-economic and environmental because it avoids the use of expensive and toxic solvents.

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