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# Fuels Coming from Locals Vegetables Oils for Operating of Thermals Engines

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**Abstract:** The energy crisis born from the oil problem determined a renewal of attention on the possible possibilities of production of substitute fuels for the operation of the machines and the thermal engines. The fuel's production based on vegetable oils require a renewal attention about the research of replacement fuel for the opeating of machines and thermal engines. Actually, the scientific world takes an interest in the research of others liquids fuel obtained with renewables energy sources whose vegetables have a good place. So, for helping to solve the fuel problem and particularly in third world countries without petroleum resources but producing fruits and oils seed, this research was about search of fuel from vegetables oils. Extraction and physico-chemical analysis performed on various vegetables plants show an interesting energy aspect. Evaluation of actually energy parameters will permit to do a comparison with classics fuel like gas-oil and petrol. Finally, analysis of thermal engines show that fuels coming from biomass like jatropha, ricinodendron and pistacia can to use for operating of those thermal engines.

**Key words:** Energy, petroleum, biomass, vegetables oils, fuel, engin

## INTRODUCTION

The petroleum energy supply constitutes a non-renewable energy, greatly used in heat engines despite its price fluctuations. The oil crisis of the years 1900 generated a renewal of attention for new types of energy said extendable for the working of the machines and the thermal engines (Norman, 1979; Deydou, 1990).

That crisis has contributed to reorient the energizing research toward other energy implores. Some researchers even consider using the plant oils and their derivatives, while others project their reflection on the alcohols and in particular the ethanol gotten from fermentation and the distillation of the cane with sugar. Indeed, chemists Sabatier and Maihles demonstrated that a process of thermal treatment of the seeds followed of a hydrogenation gives a product comparable to the crude oil (Pehaut, 1986).

This research of biomass staying a major preoccupation and of actuality, the objective of this survey was about the use of the local plant oils to know jatropha curcas, ricinodendron and pistacia, as fuel in the thermal motors whose outcome could help to solve the problem of fuel conventional in the countries of the third world, without oil resources but producers of seeds and oleaginous fruits (Oilseeds, 1983; Vattun, 1983; Riedacker, 1994). On the other hand, it could raise the economy of the countries of the third world toughly affected by the import of fuels.

## MATERIALS AND METHODS

Work achieved at the Laboratory of Engines and Machines with Energy Transformation (LMMCE) of Polytechnc National Institut of Yamoussoukro, Felix Houphouet Boigny (INP-HB). The studies are achieved on oleaginous seeds of the following plants growing in Ivory Coast. Those plants are:

- RICINODENDRON Hidelotii, plant belonging to the family of the euphorbiacies, that one designates in Ivory Coast by Apki;
- JATROPHA Curcas, plant belonging to the family of the euphorbiacies, that one designates in Ivory Coast Pourghère;
- PISTACIA Verra, plant belonging to the family of the cucurbitacies, having for common name Pistache.

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The analysis of oils were made in a chromatograph.

The study was made on the internal combustion engines.

To get a non altered oil, one will eliminate by a sorting the rotting fruits or the broken seeds and the foreign matters before passing to the extraction of oils. One must also insure that the content in water of the oleaginous seeds is lower to 10%.

One weighs approximately 5 g of vegetable matter finely crushed in a mortar. This broyat is dried with the drying oven at a temperature of 105°C until a constant weight (a difference of to the more 2 mg between two consecutive weighing).

The water content ($T_{water}$) is given by:

$$T_{water} = \frac{P - P'}{P} 100 \quad (1)$$

Where:

P = The weight of the vegetable material before stoving,

P' = The weight of vegetable equipment after stoving.

Research revolves around the following points:

- The extraction of oils from various vegetable plants;
- The physico-chimical analysis of those oils;
- The assessment of energizing parameters and the comparative study of the vegetable oil-based fuels parameters with those of ordinary fuels.

Afterwards, analysis of the thermal engines by defining the optimal calculation of engine's power.

**Extraction:** There are 2 extraction methods (Capelle, 1950):

- Extraction method by solvent (cold or hot)
- Extraction method by pressure.

In the case of this study, used method is the extraction method by cold solvent.

**Physico-chimical analysis of vegetables oils:** The chemical analysis has permitted to define (Loncin, 1977):

- Some values such the chemical rating, the iondine rating, the peroxide rating, the acidic rating, the saponification rating;
- The nature and the proportion of fatty acids and the non-saponifiable matters.

Oils contain saturated fatty acids and are just composed of carbon, hydrogen and oxygen (Table 1).

Extraction and analysis have given oils containing glyceride (95%), free fatty acids and non-saponifable matters.

**Presentation of operating of the thermal engin:** The energizing analysis of the motor will be based on the calorific powers of the fuels determined from the formula of Boie (Lemasson, 1982) permitting to do a comparison with the oil fuels in the same conditions of evaluation. The insaponifiable is not take into account in the determination of the calorific powers of the plant oils.

Theoretical power ($Pu_{th}$) equal:

Table 1: Chemical composition, fatty acids and thermal value (PCI) of oils coming from vegetable plants

| Vegetables oils | Fatty acids | Thermal value (PCI) | Chemical composition (%) |
|---|---|---|---|
| Pistacia 55-59 oil/seed | Myristic acid $C_{14}H_{28}O_2$ | | |
| | Palmitic acid $C_{16}H_{32}O_2$ | | |
| | Palmitoleic acid $C_{16}H_{30}O_2$ | | |
| | Stearic acid $C_{18}H_{36}O_2$ | | |
| | Oleic acid $C_{18}H_{34}O_2$ | | |
| | Linoleic acid $C_{18}H_{32}O_2$ | | C = 0.76495 |
| | Arachidic acid $C_{20}H_{40}O_2$- | | H = 0.11944 |
| | Gondoic acid $C_{20}H_{38}O_2H_{30}O_2$ | PCI = 36938 kJ kg$^{-1}$ | O = 0.11512 |
| Ricinodendron 45% oil/seed | Palmitic acid $C_{16}H_{32}O_2$ | | |
| | Stearic acid $C_{18}H_{36}O_2$ | | |
| | Oleic acid $C_{18}H_{34}O_2$ | | |
| | Eleostearic acid $\alpha$ $C_{18}H_{30}O_2$ | | C = 0.71100 |
| | Eleostearic acid $\beta$-$C_{18}H_{30}O_2$ | | H = 0.10713 |
| | Octadecadienoic acid $C_{18}H_{28}O_2$ | PCI = 33708 kJ kg$^{-1}$ | O = 0.10672 |
| Jatropha 13-34,3% oil/seed | Myristic acid $C_{14}H_{28}O_2$ | | |
| | Palmitic acid $C_{16}H_{32}O_2$ | | |
| | Palmitoleic acid $C_{16}H_{30}O_2$ | | |
| | Stearic acid $C_{18}H_{36}O_2$ | | |
| | Oleic acid $C_{18}H_{34}O_2$ | | |
| | Linoleic acid $C_{18}H_{32}O_2$ | | C = 0.76596 |
| | Arachidic acid $C_{20}H_{40}O_2$ | | H = 0.11893 |
| | Linolenic acid $C_{18}H_{30}O_2$ | PCI = 36901 kJ kg$^{-1}$ | O = 0.11614 |

$$Pu_{th} = 1{,}16.10^{-3}\ m_{comb\,h^{-1}}\ PC\ (\text{in Kw}) \qquad (2)$$

Where:

$m_{comb\,h^{-1}}$ = mass of fuel per hour

PC = global thermal value

The power is a characteristic size of the engin. This power depends on the combustion heat, of the calorific power therefore of the fuel.

## RESULTS AND DISCUSSION

**Analysis of energy characteristics of the engine:** Considering an average specific consumption of a diesel engine equalizes with 240 g $kw^{-1}$ $h^{-1}$. A diesel engine of 150 kw will have a consumption of fuel oil 36 g $h^{-1}$. From these results, the theoretical powers developed by the studied biocarburants can be found (Table 2).

Considering Table 2, the engine output varies according to the calorific value in the same direction as this last. Thus starting from the calorific values obtained by the chemical analysis, it arises that an engine functioning with a traditional fuel such as the fuel oil can function with a fuel at base of studied vegetable oils but in mode lower than the nominal mode. This trip could be filled while adding to vegetable oils of the ethanol bus with ethanol, one obtains a power higher of 18% than that of the gasoline (USDOE, 1991).

The fuel consumption (c) is given by the following relation:

$$c = \frac{3600}{\eta_{eff} PCI} P_{eff} \qquad (3)$$

Where:

$P_{eff}$ = effective power

$\eta_{eff}$ = effective output

The determination of consumption is written in Table 3.

Consumption according to the calorific value of each fuel coming from the biomass and the gasoil is represented in Fig. 1.

Fig. 1 shows that consumption increases when the calorific value decreases. This fact implies an engineering change of the engine to increase the rate of injection in order to increase consumption. Then, The oils coming from the biomass can validly replace the conational fuel.

Table 2: Comparison of the theoretical powers of the fuels

| Fuel | Gasoil | Jatropha curcas | Pistacia | Ricinodendron |
|---|---|---|---|---|
| PCI (kcal $kg^{-1}$) | 10048 | 8829 | 8837 | 8065 |
| $Pu_{th}$ (kw) | 419.63 | 368.70 | 369.03 | 336.80 |

Table 3: Fuels consumption (c) and thermal value of fuels

| Carburant | Gas-oil | Jatropha curcas | Pistacia | Ricinodendron |
|---|---|---|---|---|
| PCI (kj $kg^{-1}$) | 42000 | 36905 | 36939 | 33712 |
| c (kg $h^{-1}$) | 36.00 | 40.64 | 40.61 | 44.49 |

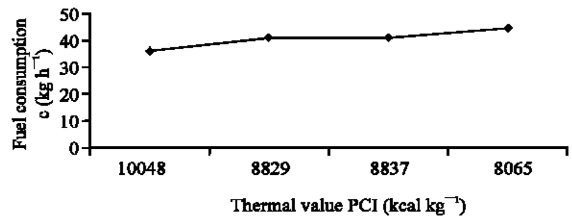



Fig. 1: Consumption (c) according to the thermal value (PCI)

**Smoke-production analysis after combustion of conventionalities fuels and vegetables oils:** The combustion of a fuel in a thermal engine is accompanied by a discharge of various gases ($CO_2$ CO, $SO_2$ $NO_X$ harmful for the environment. The increase in these gases in the atmosphere can involve climatic changes.

This takes us along to determine the quantities of produced gas of vegetables oils by following relations:

Dry smoke-producing capacity ($V_{f0}$):

$$V_{f0} = V_{CO_2} + V_{SO_2} + V_{N_2} \qquad (4)$$

Where:

$V_{CO_2} + V_{SO_2} + V_{N_2}$, respectively indicate the volume of $CO_2$ the volume of $SO_2$ and the volume of $N_2$

$$V_{f0} = 0.089\,C + 0.21\,H + 0.008\,N + 0.0335\,S - 0.026\,O_X \qquad (5)$$

$$V_{CO2} = 0.0224 = 0.01867\ C \qquad (6)$$

$$\text{Maximum content } CO_2\text{: } \alpha_0\ (\%) = 100 \qquad (7)$$

$$\text{Content of } SO_2 = 0.7\ \frac{S}{V_{f0}} \qquad (8)$$

In these various formulas, C, H, $O_X$ N and S, respectively indicate the mass percentages of carbon, hydrogen, oxygen, nitrogen and sulphur.

The given quantities of produced gas are consigned in Table 4.

Roughly speaking, the hydrocarbons composed of carbon, hydrogen, oxygen, nitrogen, sulfur (Cm Hn Ot Np Sq) are non-renewable energy supplies whereas the vegetable oils composed of carbon, hydrogen and oxygen (Cm Hn Ot) are renewable energies coming from vegetable oils. On one hand, the combustion gas got after a chemical reaction with the

Table 4: Composition of the combustion gas of the various fuels

| Fuels | $V_{CO2}$ Gives out ($Nm^3\ kg^{-1}$ of fuels) | Dry capacity smoke-production ($Nm^3$smoke $kg^{-1}$ of fuels) | Maximal content in $CO_2$ (%) | Content in $SO_2$ (%) | PCI ($KJ\ kg^{-1}$) |
|---|---|---|---|---|---|
| | Characteristics of the combustion gas and the fuels | | | | |
| Jatropha curcas | 0.01430 | 0.09013 | 15.86 | ---- | 36938 |
| Pistachia | 0.01428 | 0.09017 | 15.84 | ---- | 33708 |
| Ricinodendron | 0.01327 | 0.08300 | 15.99 | ---- | 36901 |
| Gas oil | 0.01611 | 0.10399 | 15.49 | 0.060 | 43250 |
| Petrol | 0.01596 | 0.10637 | 15.00 | 0.006 | 43700 |

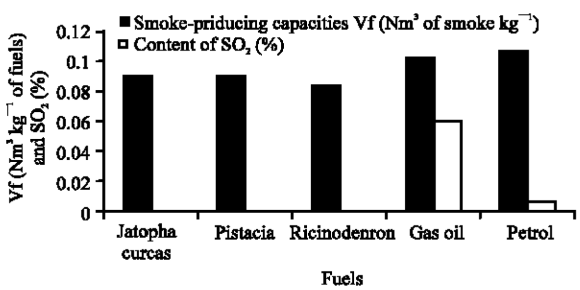



Fig. 2: Comparison of smokes Vf ($Nm^3$ of smoke $kg^{-1}$)

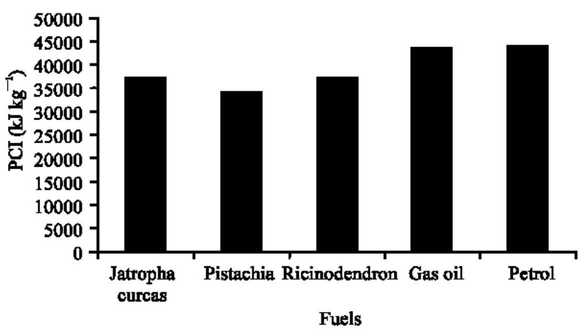



Fig. 3: Comparison thermal value (PCI) of fuels

hydrocarbons contain some $SO_2$ and $N_2$(or $NO_x$) in addition to the carbon dioxide $CO_2$, then those obtained with the vegetable oils contain only the carbon dioxide $CO_2$ (Table 4).

The combustion gas coming from hydrocarbon have a more negative chemical reaction on the environment compared to those coming from the biomass (Fig. 2). On the other hand, thermal value of fuels coming from the biomass have a more important value and closer the one of hydrocarbons (14% of difference); those fuel can replace the petrol and the gas-oil for the working of thermal engines.

On the basis of Table 4, one notices that the thermals values of fuels (PCI) coming from the biomass are close to those of conventional fuels (Fig. 3). However these fuels could be used in the thermal engines with internal combustion. Relate to consumption, it larger in the case of the bio-fuels. This can be filled by the adjustment of the engine.

For better understanding the operation of the engine, one can represent the operating features of the engine to

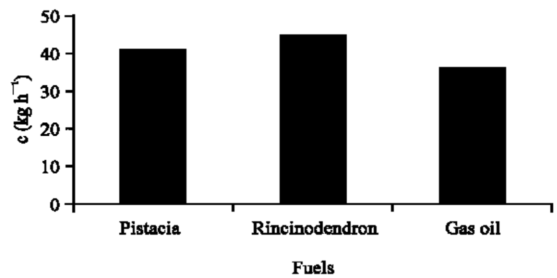



Fig. 4: Comparison of consumption (c) of fuels

knowing the calorific value (PCI) and consumption (c) on the Fig. 3 and 4 starting from Table 3 and 4.

As general rule, the heat efficiency ($\eta_{th}$) of the engine (Lemasson, 1982) is equal to:

$$\eta_{th} = 1 - \frac{Q_2}{Q_1} \quad (9)$$

Where:
$Q_1$ = incoming heat
$Q_2$ = outgoing heat

The thermal output ($\eta_{th}$) is defined by following relations:

$$-\text{for Diesel engine} \quad \text{and} \quad -\text{for petrol engine}$$
$$\eta_{th_D} = 1 - \frac{1}{\gamma}\frac{\Delta^{\gamma-1}}{\tau^{\gamma-1}(\Delta-1)} \quad \text{and} \quad \eta_{th_e} = 1 - \frac{1}{\tau^{\gamma-1}} \quad (10)$$

then, $\eta_{th} = f_1(\tau, \Delta)$

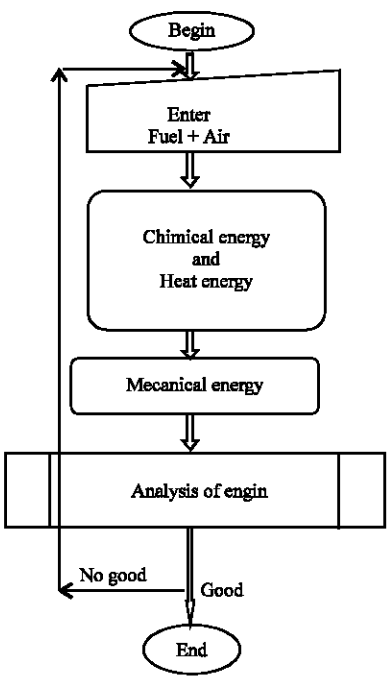
Where:
$\gamma$ = Cp/Cv
Cv = Heat-storage capacity with constant volume
Cp = Heat-storage capacity with constant pressure
$\tau$ = Compression ratio of engin ( $\tau = \frac{v_1}{v_2}$ )
$\Delta$ = Injection ratio
$f_1$ = Function of $\tau$ and $\Delta$
$\eta_{thD}$ = Hermal output for Diesel engin
$\eta_{the}$ = Thermal output for petrol engin
$v_1$ = Volume of the cubic capacity
$v_2$ = Volume of the combustion chamber

According to the 1st principle of thermodynamics, all heat energy ($\Sigma Q$) is equal to all mecanical energy ($\Sigma Em$), then, the heat efficiency ($\eta_{th}$), depending on the compression ratio ($\tau$) and is also linked to the heat brought to incoming heat ($Q_1$).

Therefore, the Mecanical Energy (Em) is also in accordance with the thermal output ($\eta_{th}$) and so, due to the fuel. The power of the engine (Pu) depending on the mecanical energy of the engine is also in accordance with the heat efficiency ($\eta_{th}$); then Power (Pu) is also in accordance with the fuel.

$$Pu = f\,(fuel) \tag{11}$$

All these researches have been registered in a calculation software of research of thermal engin.




## CONCLUSIONS

This research has permitted us to increase the value of a new kind of fuel coming from the local vegetables oils (biomass). That energy supply is renewable and could replace some energy supplies coming from the hydrocarbon such as the petrol and the gas-oil.

Thus, that new energy could make work a thermal engine and this engine, connected up to an alternating-current generator, can generate an electric energy. When this engin is coupled with a hydraulic pump it can produce a hydraulic energy.

Comparatively to the ordinary fuels, the thermal values and the consumptions are lower different than those of the biomass. That difference can be made up by adding additives in the fuels from the biomass.

Finally, concerning the environment, the combustion gas coming from vegetable oils are less pollution than those from the hydrocarbons.

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