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# Relationship between cetane number and calorific value of biodiesel from Tilapia visceral oil blends with mineral diesel

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**Abstract.** The calorific value indicates the energy available in the fuel. It is therefore an important parameter to compare the consumption of biodiesel compared to mineral diesel. Another important feature is the cetane number, which measures the ignition quality of diesel fuel. A high cetane number indicates that the fuel will ignite faster than those with a lower value of this parameter. This work aims to obtain experimentally and compare the cetane number and calorific value of different blends of biodiesel from Tilapia visceral oil with petroleum diesel (B5, B10, B15, B20 and B30). The results show that the B5 blend has the highest calorific value ($\Delta$H= 44488.0 J g$^{-1}$) followed by B10 ($\Delta$H = 44275.0 J g$^{-1}$), B15 (H = 44053.0 g J-1), B20 ($\Delta$H = 43829.0 J g$^{-1}$) and B30 ($\Delta$H = 42895.0 g J$^{-1}$). However, the B5 blend have the lowest cetane number (47.7% vol), followed by B10 blend (53.0 vol%), B15 (58.6 vol%), B20 (62.5 % vol) and B30 (73.1 % vol). The increase of the studied biodiesel in blends with petroleum diesel improves the ignition quality of these blends. However, it decreases the calorific value of this same fuel.

**Keywords** Calorific value, cetane number, biodiesel from Tilápia visceral oil blends

## 1. Introduction

Biodiesel is being developed to replace petroleum diesel and can be obtained from renewable raw materials. [1-3]. This biofuel is obtained by a transesterification reaction using triglycerides (vegetable oils and animal fats) with a short chain alcohol (methanol or ethanol are the most commonly used) in the presence of a catalyst which may be acidic, basic, metallic or biological (enzyme) producing a mixture of alkyl esters of fatty acids (biodiesel) and glycerol as a co-product [4,5].

Some properties of biodiesel are close and sometimes better compared to mineral diesel: better ignition quality, comparable energy content, higher density, flash point, almost zero sulfur, cleaner burning [6-8].

For biodiesel, two important features are calorific value and cetane number. The calorific value or heat of combustion is the amount of heat transferred to the chamber during combustion and indicates the available energy in the fuel [8,9]. It is therefore an important parameter to compare the consumption of biodiesel compared to diesel fuel on the engine performance [10].

Biodiesel has a calorific value which is about 12% lower than diesel, which means that biodiesel has lower energy content. This leads to a higher consumption of biodiesel in order to achieve yield of diesel in the engine [11].

Other important parameter is the cetane number and it is one of the most cited indicators of quality of diesel fuel. It measures the readiness of the fuel injected into the engine to ignite. It usually depends on the fuel composition and can impact the engine in relation to noise level and exhaust emissions. A high value of cetane number indicates that the fuel ignite faster [12].

The biodiesel used for this study was obtained from Tilapia visceral oil as a source of animal lipid. This raw material should be explored, since the Nile tilapia (*Oreochromis niloticus*) is one of the most important fish grown in fish farms. The production of this biodiesel can be an alternative solution to the problem that this material without economic value causes to the environment when it is discarded.

This study aims to determine experimentally and compare the cetane number and calorific value of different blends of biodiesel from Tilapia visceral oil (B5, B10, B15, B20 and B30) analyzing what kind of relationship exists between these two parameters [13].

## 2. Materials and method

The mineral diesel was kindly donated by Petrobras-Revap located at the city São José dos Campos-SP, Brazil. The biodiesel from Tilapia visceral oil was synthesized by the laboratory of the Department of Chemical Engineering of University of São Paulo.

To study the calorific it was used biodiesel from Tilapia visceral oil blends B5, B10, B15, B20 and B30 calorimeter using the combustion IKA200 (Figure 1), with 99.7% oxygen pressurized at 30 bar. Analyses were performed in triplicate.

Fig. 1. Calorimetric bomb.

The cetane number, cetane index and distillation parameters T90 and T95 of biodiesel from Tilapia visceral oil blends B5, B10, B15, B20 and B30 and diesel fuel was measured in the unit IROX DIESEL (Figure 2), calibrated with hexane 99% PA. The measuring principle is based on the methodology of infrared (IR) absorption measurement in the range of 2.7 to 15.4 μ, using a Fourier Transform spectrometer. The resulting spectrogram of this range is correlated with a matrix of the spectra of the substances to be analysed in variable concentrations. A measuring cell of 0.1 mm length is introduced in the beam of an adequate infrared source and the intensity of the beam with a sample in the cell is measured.

Fig. 2. IROX DIESEL.

## 3. Results and discussion

The results indexes of acidity, peroxide, iodine and saponification, the FFA and moisture content of the Tilapia viscera oil are shown in Table I.

Table I. - Characterization of Tilapia visceral oil.

| **Properties** | **Oil** |
|---|---|
| Acidity index (mg KOH/g) | 5.8 |
| Peroxide index (mEq/Kg) | 23.0 |
| Iodine index ($gI_2$/100g) | 72.35 |
| Saponification index (mg KOH) | 177.8 |
| Moisture (%) | 0.12 |
| FFA % | 3.11 |

For the transesterification reaction it was used 1:9 molar ratio (Tilapia visceral oil: ethanol).

By $^1$H NMR analysis shows in the region between 3.5 and 4.5 several peaks characteristic signals of lipid material (Figure 3).

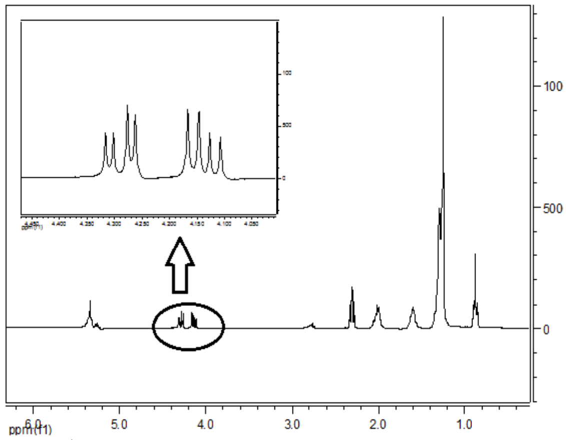


Fig. 3. $^1$H NMR spectrum of Tilapia visceral oil.

In the ethyl ester spectrum it is possible to observe which corresponds $CH_2$ quartet ethyl radical, indicating the transesterification reaction (Figure 4). Moreover, the peaks that are shown in the spectrum of the oil in the range of 4.1 to 4.3, disappear in the spectrum of ethyl biodiesel, thus showing the high yield transesterification reaction.

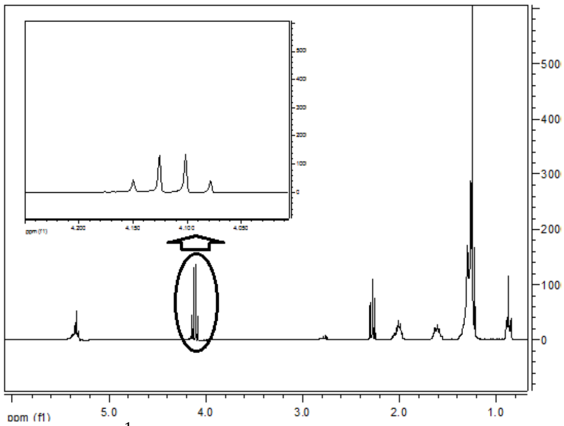


Fig. 4. $^1$H NMR spectrum of ethyl biodiesel.

The other signals are matched in the two spectra, since they represent parts that do not suffer the transesterification reaction. It can be stated that the conversion was quantitative for this biodiesel, having a high yield.

The cetane number results shows that B5 blend has the lowest value (53.0% vol), followed by B10 blend (55.9 vol%), B15 (58.6 vol%), B20 (62.5 vol%) and B30 (73.1 vol%).

The results show that the B5 blend has the highest calorific value ($\Delta H$= 44488.0 J $g^{-1}$) followed by B10 ($\Delta H$ = 44275.0 J $g^{-1}$), B15 (H = 44053.0 g $J^{-1}$), B20 ($\Delta H$ =

43829.0 J $g^{-1}$) and B30 ($\Delta H$ = 42895.0 g $J^{-1}$). Thus showing that the B30 blend has the lowest calorific value. This indicates that the higher the amount of biodiesel in the blend, the lower calorific value of the fuel (Table I).

Table I

| Combustível | 1º amostra | 2º amostra | 3º amostra | Average | S.D. (%) |
|---|---|---|---|---|---|
| **B5** | 44389 | 44533 | 44542 | **44488** | 0.19 |
| **B10** | 44333 | 44125 | 44367 | **44275** | 0.29 |
| **B15** | 44098 | 43960 | 44101 | **44053** | 0.18 |
| **B20** | 43811 | 43903 | 43773 | **43829** | 0.15 |
| **B30** | 42644 | 42788 | 43253 | **42895** | 0.74 |

Figure 5 shows that the cetane number and calorific value has an inverse relationship for the studied biodiesel blends.

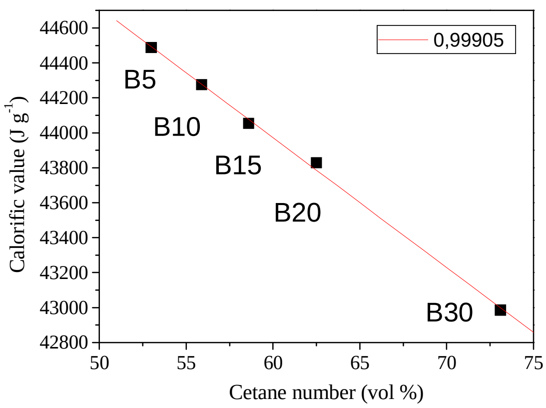


Fig. 1. Relationship between cetane number and calorific value of studied blends.

## 4. Conclusions

It can be concluded that the presence of biodiesel from Tilapia visceral oil blended with petroleum diesel improves the parameter of cetane number. This is important since a high cetane number improves the quality of combustion and decreases $NO_x$ emission. Moreover causes less noise and greater durability of the engine.

Although, the presence of biodiesel in blends leads to a reduction in calorific value requiring higher fuel consumption for a yield equivalent to mineral diesel in engines. From the experimental results it can be seen that the cetane number and calorific value has an inverse relationship for the studied biodiesel blends.

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