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Pollution analysis of castor, coconut and waste-cooking oil biodiesel blends with diesel fuel

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Abstract
Beaver oil biodiesel (CAB), coconut oil biodiesel (COB), and waste cooking oil biodiesel (WCB) are some of the biodiesels that have been created using a transesterification strategy and blended with conventional diesel fuel. We settled on volumetric blending ratios of CDF to biodiesel of 5%, 10%, 20%, and 30%. Analyses of the effects of increasing engine speed or load on the performance and emissions of turbocharged DI compressor ignition engines were conducted. This analysis took into account the impacts of varying fuel viscosity, fuel oxygen content, hydrocarbon chain length, cetane number, biological diesel fuel amount, engine speed, and load under controlled laboratory conditions that were identical to those used in the research. This study focused on the simultaneous examination of the effects of load and engine rpm on emissions of engine. The results of the experiments showed that the best emission characteristics were achieved with WCB and COB mixes, which were fuelled in diesel engines.

Keywords: Biodiesel, blending, diesel engine, load, speed, emissions

1. Introduction

There has been a shift in focus away from petroleum oil as the primary fuel source due to the oil crisis and concerns about its impact on the environment and global warming. Currently, due to the high cost of edible vegetable oils, biodiesel is being made from non-edible vegetable oils, making it a more environmentally friendly alternative fuel to diesel fuels.

As a potential solution to the issues of both fossil fuel depletion and environmental damage, biodiesel and diesel fuel mixes are now the subject of research. Biodiesel and other diesel substitutes are methyl or ethyl esters synthesized from vegetable oils or animal fats, respectively. To examine the efficiency of diesel engines, tests were conducted using biodiesel fuel made from used cooking oil.

i) Castor oil

Castor oil is an excellent substitute for biodiesel, since its plant can grow in the marginal soils and dry and semi-arid climates of many different nations. Despite the absence of protein, castor seeds are poisonous to humans and cattle. Twelve thousand and sixty hectares of land are devoted to cattle farming, yielding an average of 0.0902 kg per square meter of land each year worldwide.

ii) Coconut oil

Oil for chocolate is extracted by grilling, drying, and pressing coconut flesh that has had its husks and shells removed (copra). Between 65% and 72% of oil can be extracted from it. The 11.8 Gm^2 used for coconut cultivation spans 92 nations. According to studies conducted in 2009 by the Food and Agriculture Organization (FAO), Production in the world came in at 61.7 tg, with a yield of 0.52 kg m^{-2}. Coconut oil's many benefits include its safety, purity, cheap cost, and ease of extraction. Coconut is a great alternative feedstock for biodiesel because of its numerous useful properties.

iii) Waste cooking oil

As an alternate biodiesel source, WCO shows a lot of promise. WCO is a viable method for acquiring cheap sources of biodiesel since it reduces the price of raw materials and addresses the issue of waste oil disposal. Interest in utilizing WCO-based biodiesel has increased in every region of the world. As sunflower oil was used to create WCO for this study, it shares some of that oil's properties and may have undergone certain transformations throughout the

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food-frying process. The table below provides a concise overview of the fatty acid profiles of beaver, coconut, and vegetable oils. Beef oil is high in ricinoleic acid, an unsaturated fatty acid with 18 carbons (12-hydroxy-cis -9-octadecenoic acid). High oil viscosity and the ability to be converted into biodiesel are only two examples of the unique characteristics attributable to the presence of a 12th carbon hydroxy group.

Table 1: Fatty acid composition of castor, coconut and waste cooking oils

Fatty Acid	Formula	Castor Oil	Coconut Oil	Waste Cooking Oil
Palmitic	$C_{16}H_{32}O_2$	1.01	13.13	13.62
Stearic	$C_{18}H_{36}O_2$	1.10	3.6	5.72
Oleic	$C_{18}H_{34}O_2$	3.30	12.88	43.36
Linoleic	$C_{18}H_{32}O_2$	4.61	4.35	33.63
Linolenic	$C_{18}H_{30}O_2$	0.48	-	0.58
Eicosenoic	$C_{20}H_{38}O_2$	0.34	-	-
Ricinoleic	$C_{18}H_{34}O_3$	89.1	-	-
Myristic	$C_{14}H_{28}O_2$	-	18.38	-
Caprilic	$C_8H_{16}O_2$	-	3.35	-
Capric	$C_{10}H_{20}O_2$	-	3.31	-
Lauric	$C_{12}H_{24}O_2$	-	32.72	-
Arachidic	$C_{20}H_{40}O_2$	-	-	0.34
Others	-	0.05	8.28	2.75

2. Biodiesel production & properties

Beaver fat, cocoon oil, and leftover cooking oil were employed as biodiesel fuels in this study. Transesterification was used to produce these biodiesels. Biodiesels were manufactured by subjecting oils to a chemical reaction involving methanol (CH_3OH) and a potassium-hydroxide (KOH; 1% of oil by weight) catalyst. The concentration of methanol is always three times the stoichiometric value. The chemical industry often discards glycerol as a byproduct. The reactions were carried out at temperatures about room temperature and pressures slightly over the point at which methanol begins to boil (70 °C). With just the force of gravity, the mixture will separate in a bowl after an hour of steady churning. After a whole day of being pulled down by the Earth, two distinct strata have formed. A layer of biodiesel (ester) was on top, followed by a layer of glycerol. When the two layers were separated, the latter was washed three times in distilled water, and then heated to 110 degrees C to remove the alcohol and the water. The physicochemical qualities of biodiesel were tested using the ASTM standards, in addition to cocoon and waste cooking.

Studies have shown that while the engine cannot be fed by a conventional CAB blend due to its unusual properties, a reduced proportion of castor oil biodiesel may still be used. The exceptionally low cloud and pour points of CAB provide remarkable cold flow qualities (252 K and 234 K respectively). The fuel has shown itself effective even in subzero winter conditions.

3. Test bed configuration and test procedure

Evaluating the biodiesel's impact on engine emissions requires a test setup similar to that seen in Fig. 1. In this experiment, we used a computerized data collection system and a water-cooled, direct-injection, four-cylinder, four-stroke, turbo-charged diesel engine to mimic real-world circumstances in the agricultural industry. The engine's primary technical requirements are shown in Table 2. When gasoline was combined and stored in tanks, the cell was used to manage engine speed and load. The aforesaid objective required first and foremost the data mining test conducted at 2000 rpm motor speed and 100% load. For 15 minutes, the engine was warmed to equilibrium conditions, then the outputs were locked and data mining was performed. Data mining had a role, too. After collecting data at 100% load, 75%, 50%, and 25% loads were extracted at the same engine speed. Finally, the identical procedure was put to the test for a variety of engine RPMs and loads.

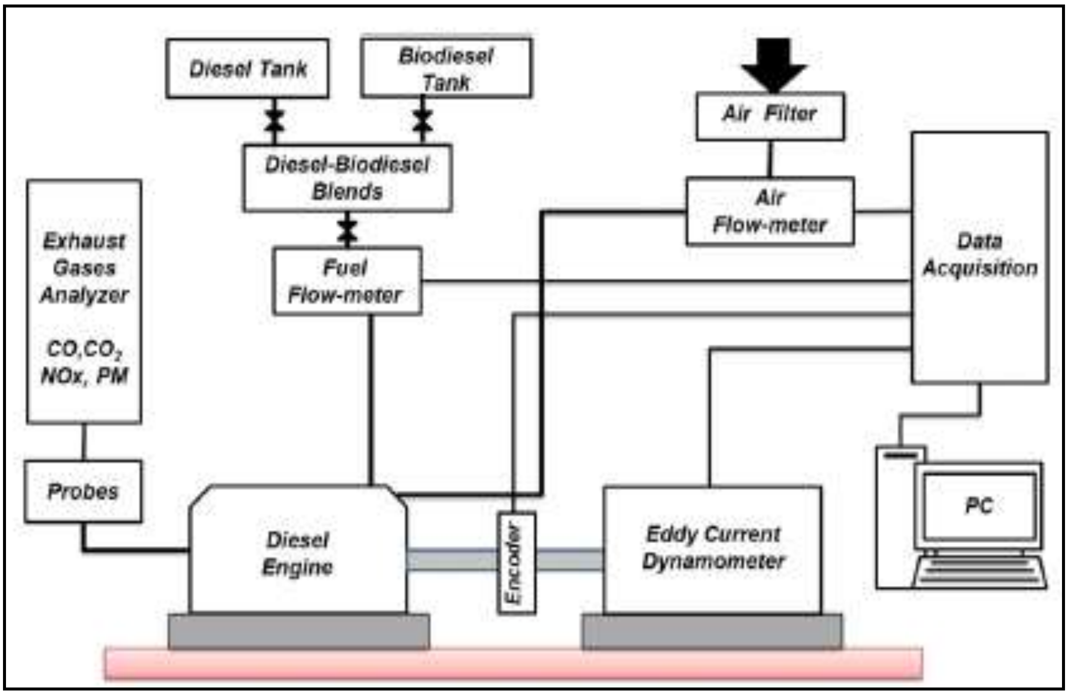


Fig 1: Schematic diagram of Test Setup

Table 2: Engine Technical Specifications

Make	Motorsazan
Model	MT4.244
Bore x Stroke (mm)	100 x 127
No. of Cylinders	4
Volume Capacity	3.99×10^{-3} m^{-3}
Cycle	4 stroke
Aspiration	Wastegate Turbocharger
Combustion System	Fast ram direct injection
Compression Ration	17.25:1
Max. Power	61.14 kW in 2000 rpm
Fuel Pump	Bosch Rotary with Boost Control
Governing	Mechanical
Cooling	Water, Belt Driven Water Pump
Weight (kg)	265
Length x Width x Height (mm)	678.7 x 655 x 748.5

Loads of 25%, 50%, 75%, and 100% were used in the trials, as well as 100% of the maximum speed and 100% diesel fuel., 5% biodiesel, 10% biodiesel, and 90% diesel by volume) (1,200, 1,400, 1,700, 2,000 rpm). Measurements were taken on the emissions of engines running on CAB, COB, and WCB blends against those running on standard gasoline.

The testing was done without making any changes to the engine. All of the tests were performed in a steady condition. The engine was warmed for at least 15 minutes before each reading to flush out any residual test gasoline from the fuel system.

The figures shown here are mean averages of three separate calculations. Each study was repeated thrice.

4. Results and Discussion

1) Particulate matter (PM) emission

Using fuel made from biodiesel or a combination of biodiesel reduces particulate matter (PM) in the engine's exhaust. Fig. 1 displays average PM shifts at different rates for four loads of 25, 50, 75, and 100%, for three sample batches of tested biodiesel. In comparison to diesel, the PM concentration of COB20, WCB20, and CAB20 fuels drops by 43.1%, 40.06 percent, and 45.67 percent, respectively. Due to an increase in the oxygen content of the combustible, the percentage of PM in diesel fuel drops below 75% for COB5, COB10, COB20, and COB30 fuels, to 22,44, 31,05, 4,03, and 48,83%, respectively. The average particulate matter (PM) increased across all loads in three biodiesel experiments shown in Fig. 2. After all, PM values of 39.7, 43.2, 42.7, and 26.45% are all lower with WCB30 gasoline at speeds below 1200, 1400, 1700, and 2000 rpm, respectively.

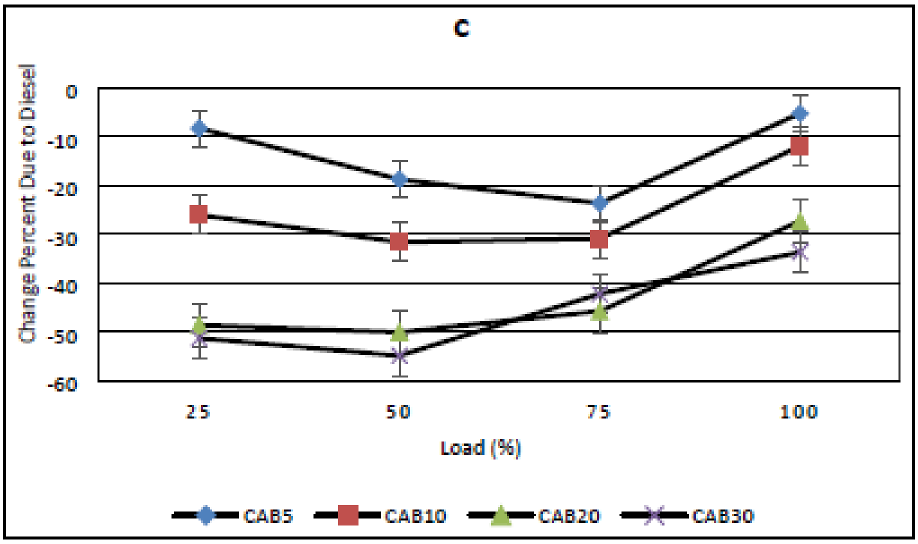
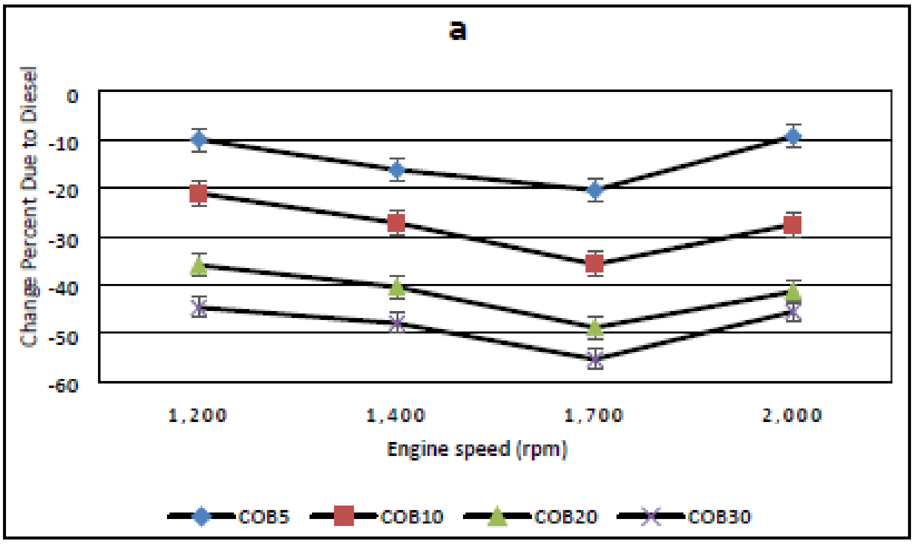
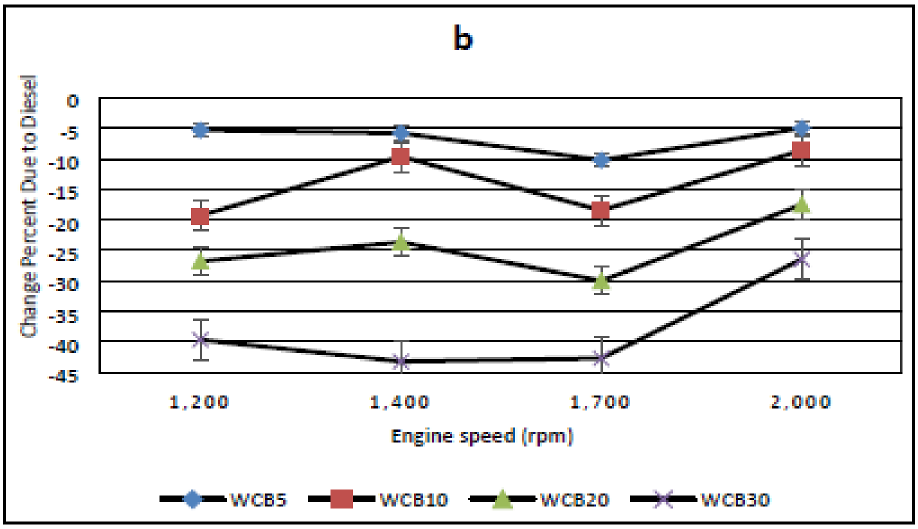


Fig 1: Changes of PM of three samples of castor oil biodiesel w.r.t. diesel against load





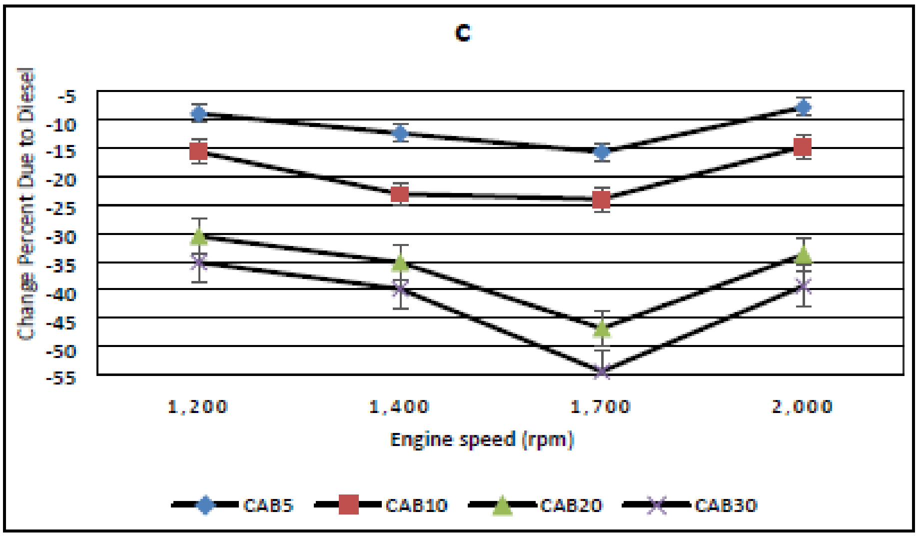


Fig 2: Changes of PM of three samples of biodiesel with respect to diesel against speed. Coconut oil biodiesel, Waste cooking oil biodiesel & castor oil biodiesel

2) NOx Emission

As biodiesels are oxygenated materials, they boost combustion and total combustion temperature within the combustion chamber, resulting in an increase in NOx emission due to the broken N2 molecules and higher temperatures produced. An increase in the percentage of biodiesel in the fuel components causes an increase in the amount of NOx released into the atmosphere, as seen in Figs. 3 and 4. For example, CAB5, CAB10, CAB20, and CAB30 loaded less than 75% were affected by fuel price increases of 5.82, 11.61, 20.45, and 26.17 percent, respectively.

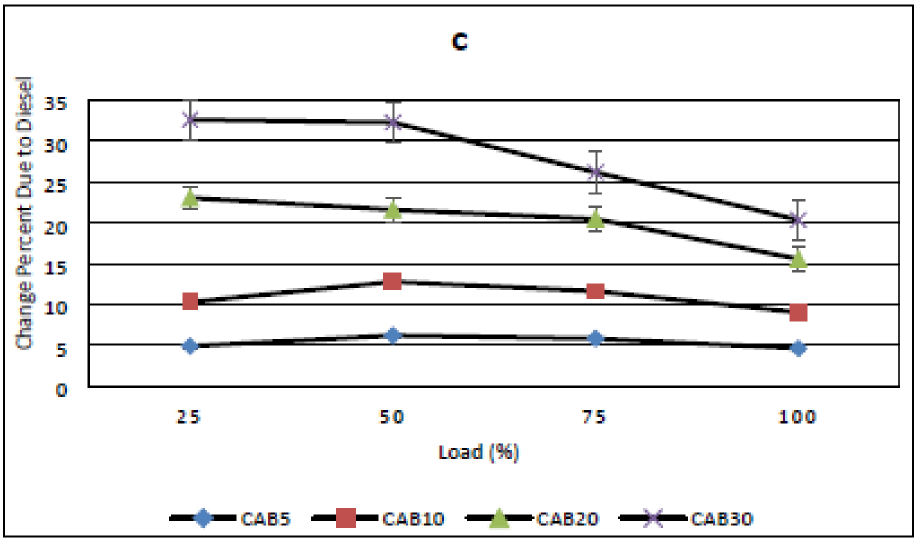


Fig 3: Changes of NOx of castor oil biodiesel with respect to diesel against load

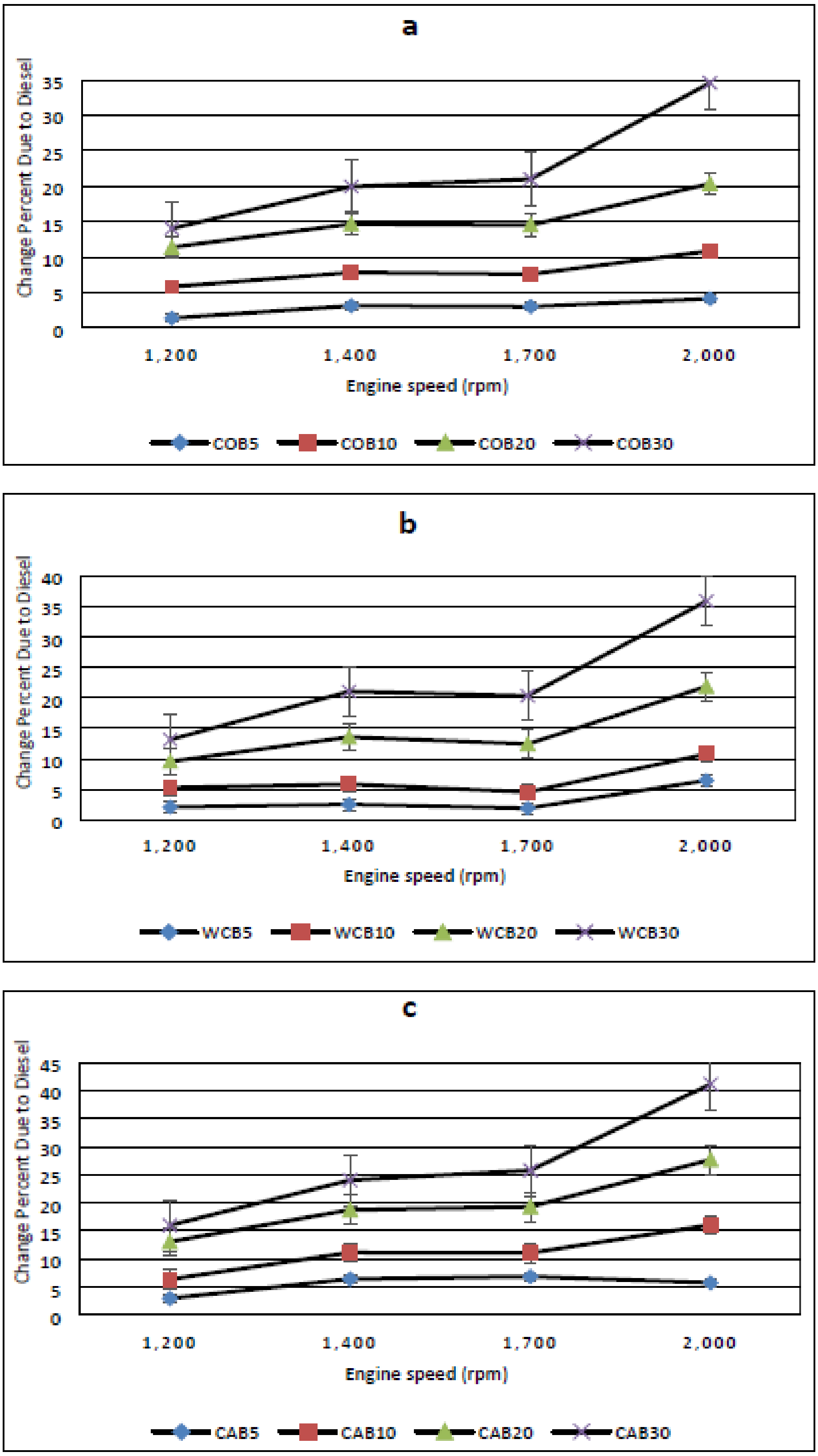


Fig 4: Changes of NOx of three biodiesel samples compounds with respect to diesel against speed. coconut oil biodiesel, Waste cooking oil biodiesel, & castor oil biodiesel

3) CO emission

Carbon monoxide average fluctuations about ethanol are shown in Fig. 5. As a percentage of gasoline, carbon monoxide's value drops. The percentage of carbon monoxide (CO) in COB5, COB10, COB20, COB30, and diesel fuel drops below 100% to 5.7, 15.76, 29.4, and 35.7 percent, respectively. For fuel with loads of less than 75%, the corresponding lower values for COB10, WCB10, and CO are 23.11, 19.3, and 14.35 percent, respectively CAB10. 50, 75, and 100 percent of the fuel generated from WCB30 oil emits less carbon monoxide than diesel does at those respective percentages.

Figure 6 displays the typical range of CO values for different diesel loads, fuel compounds, and speeds. Increasing velocity expels CO.

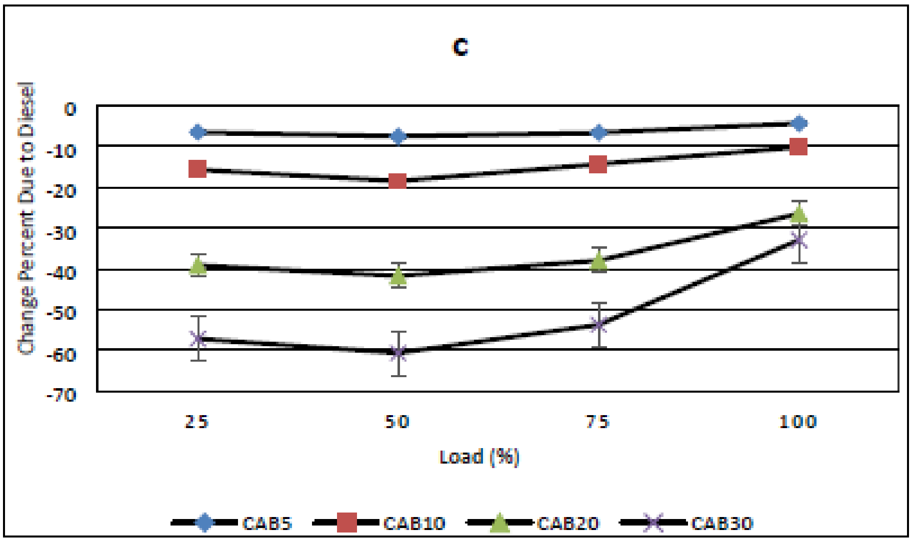
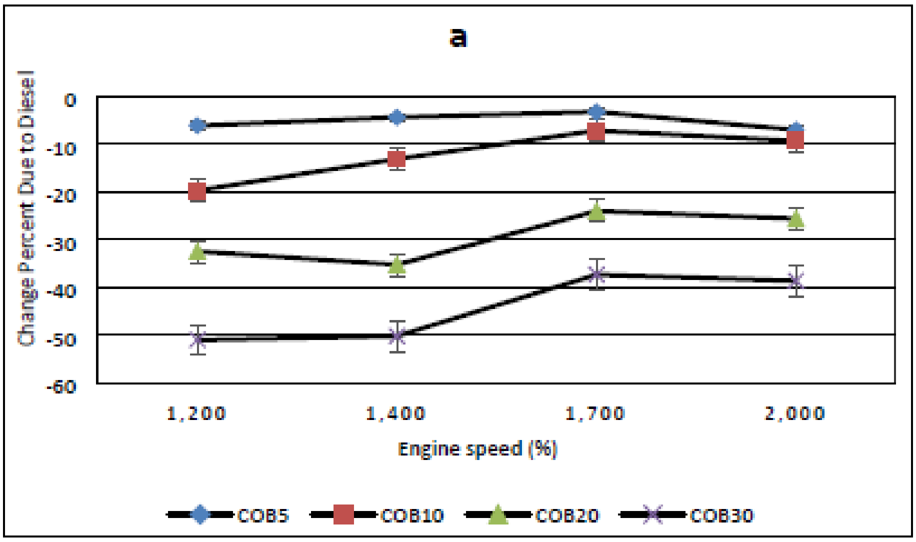
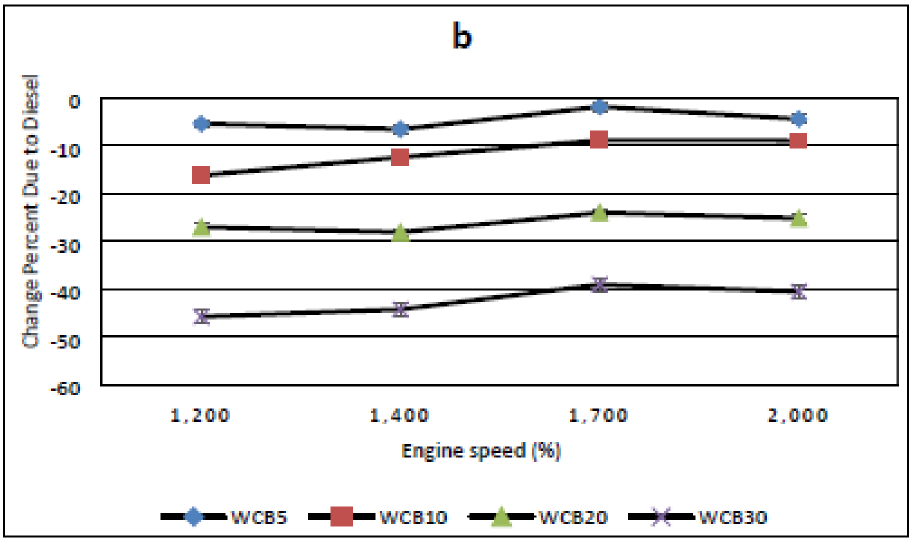


Fig 5: Changes of carbon monoxide castor oil biodiesel W. R. T. to diesel against load





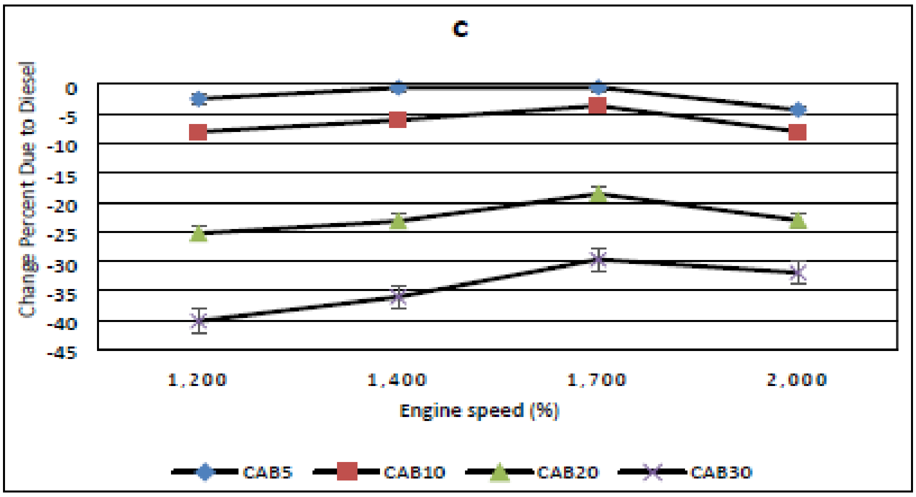


Fig 6: Changes of CO of three biodiesel samples compounds with respect to diesel against speed. coconut oil biodiesel, Waste cooking oil biodiesel & castor oil biodiesel

4) CO_2 emission

Figure 7 shows the average reduction in CO_2 emissions from three distinct biodiesel samples as a result of varying engine loads.

Given that the carbon-hydrogen ratio of WCB, COB, and CAB is equal to 0,517, 0,463, and 0,529, respectively, and that the cocoa biodiesel weighs 77%, 74.3%, 79.5%, and 79.5 respectively, the CO_2 reduction attributed to cocoa biodiesel is the largest.

CO_2 emissions are decreased by 32.2% compared to Diesel at 75% load when using COB30 or WCB30 fuel, and by 29.04% and 29.56%, respectively.

In Fig. 8, we saw that the ratio of diesel's CO_2 emissions to engine speed was decreasing over time. When engine speed increases, CO_2 emissions fall.

At 1,200, 1,400, 1,700, and 2,000 rpm, respectively, CAB30 reduces diesel-related CO_2 emissions by 9.6, 23.6, 21.7, and 16.1 percent**.**

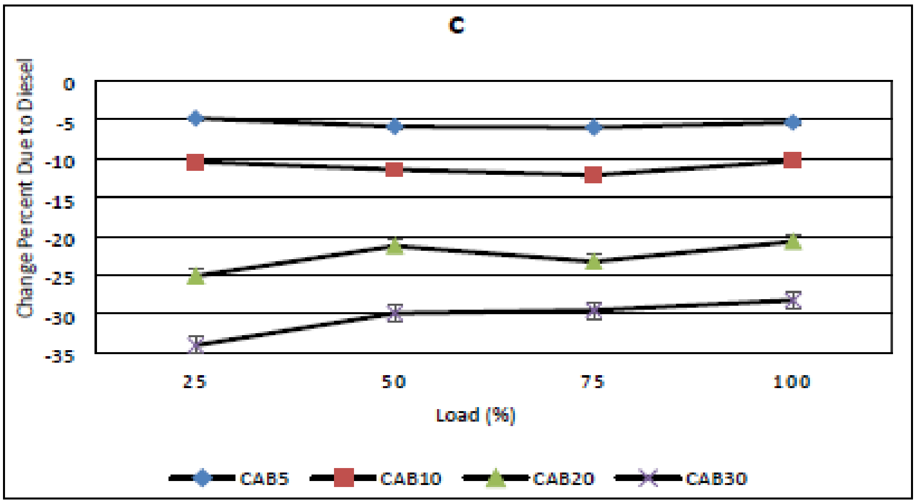


Fig 7: Changes of carbon dioxide of castor oil biodiesel W. R. T. diesel against load

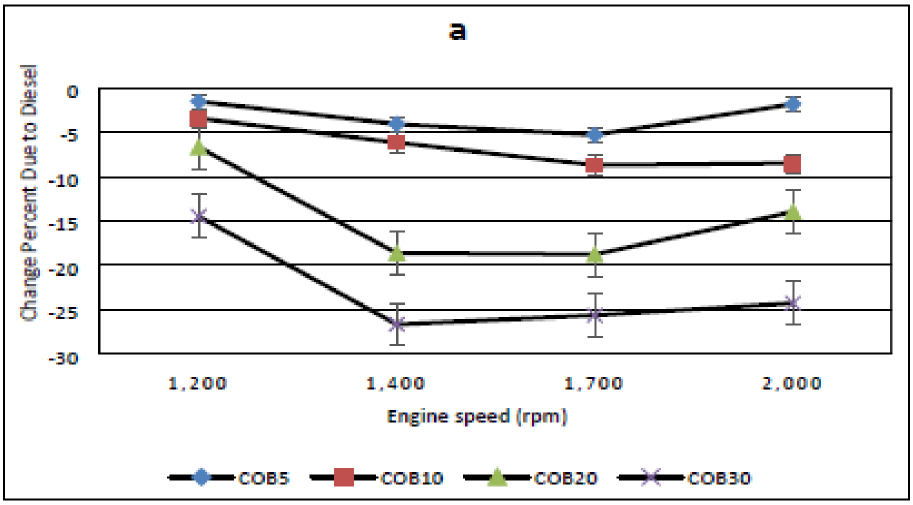


Fig 8: Changes of carbon dioxide of coconut oil biodiesel w. r. t. to diesel against speed

4. Conclusion

- When using a combination of diesel and waste cooking oil, caster oil, or coconut oil, the emission drops when the vehicle's speed and load are both changed at once
- Particulate matter (PM) levels in engine exhaust gases are reduced when biodiesel and its diesel compounds are used. At all speeds above around 2000 rpm, the PM content begins to diminish.
- In motors, biodiesel increases NOx emissions. Diesel at increased load and simple 30% combustion of this fuel produces lower NOx than waste-cooking biodiesel; caster has the highest NOx shift rate of all the fuels examined. Except at 1,200 rpm, exhaust NOx decreases with increasing engine speed.
- Higher percentages of fuel compounds result in a reduced carbon monoxide rate. The biodiesel cooking waste produced after making biodiesel cocoa has the greatest reduction in CO, while the biodiesel produced from casters shows the least variation in diesel content.
- Relative to diesel, the fuel components in the exhaust gases of the three biodiesel samples are lower with increasing CO_2. Cocoa biodiesel combustion results in the highest reduction in CO_2, followed by biodiesel cooking waste and biodiesel ricking. Adding biodiesel to compound fuels causes a decrease in carbon dioxide emissions. Increasing engine speeds reduce CO_2 emissions, but increasing motor load increases CO_2 emissions.

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