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# Performance and emission characteristics of n-pentanol mixed with premium motor spirit and camphor blend in a spark ignition engine

Faisal Omar Mahroogi*, M.U. Kaisan**, Ameh David Ameh***, Shitu Abubakar ****, S.Narayan***** and Ibrahim Umar Ibrahim******

** Department of Mechanical Engineering, Islamic University of Madinah, Saudi Arabia*

***, ***, ****, ****** Department of Mechanical Engineering, Ahmadu Bello University, Zaria, KadunaState, Nigeria.*

****** Department of Mechanical Engineering, Qassim University, Saudi Arabia*

***** Corresponding Author : rarekv@gmail.com*

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## ABSTRACT

In this work, pentanol and camphor blended with petrol in different proportions were used in spark ignition engines to evaluate their performance, characteristics, and emissions. Sample P0A (gasoline) showed the best specific fuel consumption at a relatively low torque (3 Nm) with a value of 19.2 kg/kWh. Sample P0B (100% pure gasoline and 5% camphor) had the best fuel consumption at a relatively high torque (6 Nm) with a value of 12.9 kg/kWh. For brake thermal efficiency, sample P0B had the best brake thermal efficiency at the two-constant torque, with a value of 0.34 at a torque of 3 Nm and of 0.65 at a torque of 6 Nm. Sample P15A (85% gasoline and 15% pentanol) yielded the best BMEP at a torque of 3 Nm with a value of 1.97 bar, and sample P5C (95% gasoline and 15% pentanol) yielded the best BMEP at 6 Nm with a value of 3.87 bar.

**Keywords**: Camphor; Gasoline; Engine Emission; Pentanol; Camphor; Engine performance.

## INTRODUCTION

As poor fuel quality may be measured by engine emissions, where these emissions pose a threatto our environment, different sources of energy are being explored as economical and sustainable options (Ibrahim et al. 2020). Improving the quality of these fossil fuels is considered a moderate solution. Various research groups have investigated numerous approaches to find or develop a new or improved fuel that will suit and conform to environmental guidelines, promoting sustainability and maintaining a healthy environment for all.

Nagarajan et al. (2021) investigated the effect of the addition of pentanol with Karanja biodiesel. Thebrake thermal efficiency was found to increase, whereas the brake specific fuel consumption decreased with an increase in the concentration of pentanol. Rangabashiam et al. (2020) investigated the effects of oxygenated additive blends in diesel engines. A reduction in HC emissionswas observed. Rathinam et al. (2019). examined the addition of butanol on the emissions patternof neat neem oil biodiesel (NBD100)-fueled diesel engines. Devaraj et al. (2020) investigated the use of dimethyl carbonate (DMC) as an additive. Carbon monoxide (CO) and hydrocarbon (HC) emissions decreased. Ganesan et al. (2020) found that the addition of a proportion of biodiesel–diesel blend (A20) could substantially reduce emissions. Devarajan et al. (2020) investigated the emissionsfrom an engine operated by using neem oil methyl ester (N100) as a blend. By doping 20% pentanol into neem oil biodiesel, reductions in HC and CO were observed.

Researchers have discussed and reported the use of fuel additives and blending fuels with other fuels, with most findings showing improvements, leaving room for further research(Prabhu et al. 2019). There were increases of 31.8% for BPro20 and 40.9% for BPEN20.

A study revealed that relatively great 1-pentanol blends impaired engine performance and reduced NOx emissions by 16.7% for the P30D70 mix (Santhosh et al. 2020). With relatively great alcohol (butanol) levels (Rathinam et al. 2019), engine emissions of NOx, HC, and CO were dramatically reduced by 6.8%, 10.4%, 8.6%, and 5.9%, respectively. A ternary blend of pentanol/safflower oilbiodiesel/diesel fuels was tested for performance, emissions, and combustion properties (Yesilyurt et al., 2020). The results showed that ternary mixes had higher BSFC and lower NOx emissions than Petro-diesel. Conversely, Rangabashiam et al. (2020) compared the influences of different fuel additives—di-methyl-carbonate (DMC) and pentanol (n-P)—on the ignition patterns ofbiodiesel/diesel blends in diesel engines and found significant improvements in the performance of the engine, including a reduction in engine brake specific fuel consumption by a magnitude of 0.3 and an increase in engine brake thermal efficiency by a magnitude of 0.6. By using butanol as an oxygenated ingredient to Calophyllum inophyllum (Punnai) biodiesel, Devarajan et al. (2019) found that NOx, CO, and HC emissions were reduced relative to unblended biodiesel. Atmanli and Yilmaz (2020) found that adding propanol and pentanol to waste oil biodiesel increased brake specific fuel consumption and reduced thermal efficiency (Atabani and AL Kulthoom 2020). Studying the effects of combining fuels with alcohols is necessary, as the results were encouraging (Appavu et al. 2020). The addition of pentanol to diesel and biodiesel reducedengine brake power and torque while improving CO, NOx, and smoke opacity by 41.76%, 27.6%, and 32.4%, respectively, when using Jatropha biodiesel with pentanol. For example, (Devaraj et al. 2020) found that 10% and 20% doping of pentanol with cashew nut biodiesel reduced engine emissions relative to pure CNBD. A similar engine pollution reduction result was reported by Kaisan et al. (2017). Ibrahim et al. (2020) investigated the effects of combining pentanol in modest percentages with Moringa oleifera biodiesel, finding that while fuel quality and engine brake power improved, NOx emissions

increased. (Elfasakhany 2015) found that blending isobutanol with gasoline lowered engine cylinder pressure, brake power, and exhaust gas temperature relative to pure gasoline. The effects of 1-butanol and 2-propanol combined with rapeseed oil on a diesel engine were studied by (Laza and Bereczky 2009). According to the results, adding butanol reduced NOx emissions, while adding 2-propanol increased these emissions. Alcohol blends also reduce the diffusion phase time while boosting the combustion kinetic intensity. (Elfasakhany and Mahrous 2016) compared the performance of dualn-butanol and iso-butanol additives to a single alcohol blend and found that a dual alcohol blend had the best engine performance.

Many scholars (Kumar et al., 2019) have explored the effects of injection pressure on the combustion parameters of a biodiesel engine using cerium oxide nanoparticles as a fuel additive. Theresearchers discovered that adding cerium oxide nanoparticles to biodiesel enhanced engine combustion properties, such as the peak pressure and heat release rate. The best engine performance was obtained at a 240-bar injection pressure with an 80-ppm nanoparticle concentration. The effects of propanol and camphor on spark-ignition engine performance and emissions were examined and compared (Kaisan et al. 2020). Propanol and camphor improved thermal efficiency, specific fuel consumption, and engine brake power. Similar research (Kaisan et al. 2020) revealed that adding 5 g of camphor improved fuel physicochemical qualities and engine performance better than adding butanol while reducing engine pollution.

The effect of camphor and pentanol as gasoline additives will be studied. Because camphor is widely used in SI engines in Nigeria, little research has been conducted on its use as a fueladditive; herein, we compare the effects of camphor and pentanol on engine performance and emissions to determine which has the potential to improve engine performance.

Camphor is derived from the wood camphor laurel, Cinnamomum camphora, which is native to China and Taiwan. Camphor is an organic substance that is white in colour. Camphor is used to cure fungal infections, relieve pain and irritation, and minimize coughing (Hamidpour et al. 2013). Camphor is an organic substance that is whitish in colour. The engine performance and emissions will be monitored and studied. Traditionally, truckers add camphor to their gasoline tanks to minimize fuel usage and emissions.

## Materials, equipment, and methodsSample preparation

Camphor was first powdered. Samples P0A, P15B, and P15C were prepared for this study. Camphor (0 g, 5 g, and 10 g) was added to each of the first three samples. The blends were P0A, P0B, and P0C. The next three samples were filled with 95% petrol and 5% n-pentanol, with 0 g, 5 g, and 10 g of camphor, and labelled P5A, P5B, and P5C, respectively. Camphor in proportions of 0 g, 5 g, and 10 g was added to the samples labelled P10A, P10B, and P10C, respectively, as shown in Table 1. Finally, three further samples containing 15% n-pentanol each were created, with 5 g and 10 g of camphor added to two of the mixes, labelled P15B and P15C, respectively.

**Table 1. Nomenclature of the samples**

| **S/n** | **Sample Prepared** | **Compositions of samples** | | |
|---|---|---|---|---|
| | | **PMS Content in the Blend %** | **N-pentanol Content in the Blend %** | **Camphor Added** |
| 1. | P0A | 100.00 | - | - |
| 2. | P0B | 100.00 | - | 5.00 |
| 3. | P0C | 100.00 | - | 10.00 |
| 4. | P5A | 95.00 | 5.00 | - |
| 5. | P5B | 95.00 | 5. 00 | 5.00 |
| 6. | P5C | 95.00 | 5.00 | 10.00 |
| 7. | P10A | 90.00 | 10.00 | - |
| 8. | P10B | 90.00 | 10.00 | 5.00 |
| 9. | P10C | 90.00 | 10.00 | 10.00 |
| 10. | P15A | 85.00 | 15.00 | - |
| 11. | P15B | 85.00 | 15.00 | 5.00 |
| 12. | P15C | 85.00 | 15.00 | 10.00 |

### Experimental procedure for performance and emission test

The fuel blends were tested on an engine with the specifications shown in Table 2. The generallayout of the test engine is shown in Figure 1.

**Figure 1. Experimental setup for the performance and emission test analyser setup**

**Table 2. Specification of the engine manufactured by T-equipment technology**

| | |
|---|---|
| **Engine type** | 4-stroke single cylinder engine |
| **Net power** | 4.5 kW at 3600 rpm |
| **Weight** | 27 kg |
| **Speed** | Approximately 3600 rpm |
| **Engine capacity** | 208 cc |
| **Net torque** | 12.5 Nm at 2800 rpm |

Figure 2. Brake power at 3 Nm and 6 Nm

The effects of incorporating camphor into gasoline on the engine brake power are depicted in Figure 2. The addition of camphor alone produces only a slight difference in engine brake power relative to P0A, but the combination of camphor and pentanol produces a significant difference in engine brake power. Sample P0B at 6 Nm produces a significant improvement, with an increase of approximately 1.8%; sample P5B with 5% pentanol and 5 g of cayenne produces a significant improvement, with an increase of approximately 1.8%.

**Specific fuel consumption**

Specific fuel consumption is defined as the ratio of the mass flow rate of fuel into the engine-to-engine brake power (Kaisan et al. 2017). The effects of camphor–pentanol blends with gasoline on specific fuel consumption are presented in the figure for both engine torques of 3 Nm and 6 Nm.

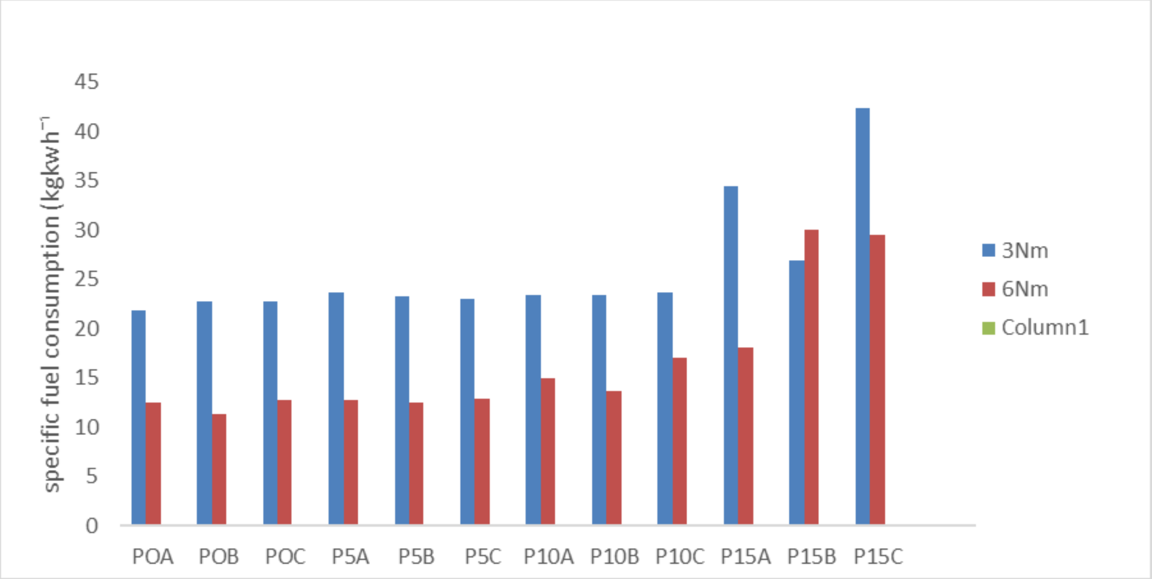

**Figure 3.** Specific fuel consumption

According to Figure 3, the sample with the lowest specific fuel consumption at 3 Nm is petrol (POA), with a value of 19.2 kgkwh$^{-1}$; at 6 Nm, the sample with the lowest specific fuel consumption is diesel (POB), with a value of 12.9 kgkwh$^{-1}$. These results demonstrate that the addition of camphor and pentanol increases engine specific fuel consumption; this increase is noticeable at each engine torque, with the highest increase in engine specific fuel consumption recorded by sample P15C, which is approximately 94.3% higher than the pure gasoline fuel.

## Brake thermal efficiency

A small or absent increase in engine brake thermal efficiency can be observed at each engine torque tested, with the addition of camphor additives to pure petrol; with the addition of pentanol, the engine brake thermal efficiency decreases significantly at each engine torque tested. The lowest engine brake thermal efficiency is recorded by sample P15B with an approximately 37% reduction relative to pure gasoline fuel at 6 Nm, as shown in Figure 4.

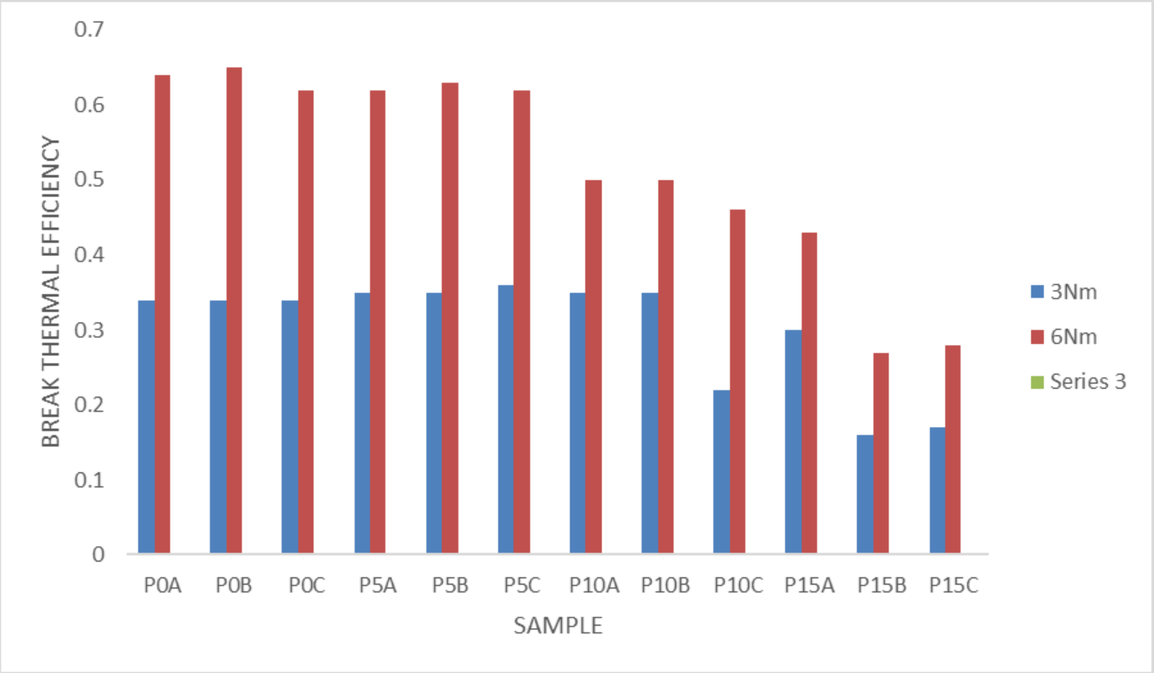

**Figure 4.** Break thermal efficiency

**Brake Mean Effective Pressure (BMEP)**

**Figure 5. Break mean effective pressure**

Figure 5 shows the engine brake mean effective pressure (BMEP). Sample P15A shows the highest BMEP at engine torques of 3 Nm and 6 Nm with a value of 3.97 bar. At 3 Nm, BMEP has a value of 1.97 bar. Samples P0B and P0C appear to have values similar to those of P0A despite having 5 g and 10 g of camphor added.

## Conclusion

From the experimental results presented herein, we concluded that the addition of camphor and pentanol to conventional gasoline both affected the combustion process. P0B was the best blend in terms of engine performance, showing the best engine power and engine brake thermal efficiency. All blends performed effectively in terms of the brake mean effective pressure. In general, we concluded that the addition of pentanol as an oxygenate reduced engine emissions relative to pure gasoline. This finding could go a long way in selecting the best blends to use in solving recent environmental problems resulting from the use of Petrol.

## ACKNOWLEDGEMENTS

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