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The Effect of Octane Booster and Nitro Race Additives on Engine Performance and Fuel Consumption of 110 CC Motorcycle Engine: An Experimental Approach

Darmulia[1]
Universitas Islam Makassar, Indonesia

Obet Ranteallo[2*]
Universitas Cenderawasih, Indonesia

***Corresponding author:**
Obet Ranteallo, Universitas Cenderawasih, Indonesia.
✉obet_ranteallo@ft.uncen.ac.id

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Abstract

Background: Fuel quality and combustion characteristics are important factors that influence engine performance and fuel efficiency in spark-ignition engines. The use of fuel additives is one method commonly applied to improve combustion quality.
Objective: This study evaluated the comparative effects of STP Octane Booster and Nitro Race additives on the engine performance and fuel consumption of a Honda Scoopy 110 cc motorcycle.
Methods: A quantitative experimental method was employed using a 2022 Honda Scoopy 110 cc engine. Pertalite (RON 90) and Pertamax Turbo (RON 98) were blended with both additives at five concentration levels (5–25 ml/L). Performance parameters, including torque, power, fuel consumption, specific fuel consumption (SFC), and thermal efficiency, were measured using a chassis dynamometer.
Results: Higher additive concentrations consistently increased torque and effective power while reducing fuel consumption and SFC. The combination of STP Octane Booster and Pertamax Turbo yielded the best overall performance among all tested mixtures.
Conclusion: STP Octane Booster combined with high-octane fuel positively improved combustion quality and engine performance. These findings suggest that commercially available octane boosters can serve as a cost-effective approach to optimizing fuel efficiency in small motorcycle engines.

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INTRODUCTION

The increasing demand for fuel-efficient and environmentally friendly transportation has encouraged extensive research on combustion improvement in spark-ignition engines. According to Statistics Indonesia (Indonesia, 2023), the number of registered motorcycles in Indonesia exceeded 130 million units in 2022, accounting for approximately 82% of all motor vehicles. This massive motorcycle fleet contributes to roughly 40% of national fuel consumption in the transportation sector (Kementerian ESDM, 2022). Consequently, even marginal improvements in combustion efficiency can yield substantial aggregate fuel savings and emission reductions at the national level. In gasoline engines, fuel quality plays an important role in determining combustion characteristics, engine performance, fuel efficiency, and exhaust emissions. Parameters such as torque, brake power, brake-specific fuel consumption, and thermal efficiency are strongly influenced by the combustion quality inside the combustion chamber (Ganesan, 2022; Heywood, 2018; Khedr et al., 2025; Stone, 1999). Poor combustion quality may result in incomplete combustion, unstable flame propagation, and a tendency toward engine knock, which can reduce engine efficiency and accelerate engine component wear.

Motorcycles are among the most widely used modes of transportation in developing countries, including Indonesia, due to their affordability and operational efficiency. Along with the rapid growth in motorcycle use, fuel consumption and exhaust emissions have also increased significantly. Therefore, efforts to improve combustion efficiency and optimize fuel utilization have become important issues in automotive engineering research. One approach widely applied to improve combustion characteristics is the use of fuel additives.

Fuel additives are chemical substances added to fuel in small quantities to enhance fuel properties and combustion performance. In spark-ignition engines, octane booster additives are commonly used to increase the octane rating, stabilize combustion, and improve resistance to auto-ignition during compression (Gupta, 2025; Pulkrabek, 2004; Stone, 1999). Higher-octane fuel generally produces more stable combustion and improves engine efficiency, particularly under high engine load and high-speed conditions. Several studies have reported that the use of fuel additives can improve engine power output, reduce fuel consumption, and enhance thermal efficiency (Elfasakhany & Mahrous, 2016; Mohan et al., 2024; Yusuf & Inambao, 2021).

Research on fuel additives and alternative fuel mixtures has shown promising results in improving combustion quality and engine performance. Koç et al. (2009) reported that ethanol–gasoline blends improved combustion efficiency and reduced exhaust emissions in spark-ignition engines (Ansari et al., 2025). Similarly, Cabir (2024) found that fuel mixtures with higher-octane characteristics contributed to improved engine performance and fuel economy. Agarwal (2007) also emphasized that fuel modification and additive utilization can significantly affect combustion characteristics, thermal efficiency, and engine durability (Vinothkumar et al., 2026). These studies indicate that fuel additives and fuel-quality enhancement remain important approaches to improving engine operational efficiency.

Elfasakhany (2016) reported that fuel additives significantly affect combustion efficiency and exhaust emission characteristics in spark-ignition engines. Similarly, Mohan et al. (2024) demonstrated that octane-enhancing additives contributed to improved engine performance and combustion stability. In addition, Aprianto and Irawan (2021) found that additive utilization can reduce brake-specific fuel consumption in gasoline engines (Ananda, 2025). Other studies conducted by Maridjo and Angga (2019) also revealed that fuel octane rating has a strong influence on engine performance characteristics, particularly torque and brake power output (Ananda, 2025).

Table 1. Summary of Previous Research on Fuel Additives and Engine Performance

Author	**Variables Tested**	**Main Results**
Koç et al. (2009)	Ethanol-gasoline blends, SI engine	Improved combustion efficiency, reduced emissions (Ansari et al., 2025).
Agarwal (2007)	Biofuel additives, CI/SI engines	Fuel modification affects combustion, thermal efficiency, durability (Vinothkumar et al., 2026)
Çabir (2024)	Ethanol-gasoline, fuel octane	Improved performance and fuel economy
Mohan et al. (2024)	Octane-enhancing additives, SI engine	Improved performance and combustion stability
Elfasakhany (2016)	Fuel additives review, SI engines	Significant effect on combustion efficiency and emissions (El-Adawy et al., 2026).
Maridjo & Angga (2019)	Premium, Pertalite, Pertamax, 4-stroke engine	Octane rating strongly influences torque and power (Ananda, 2025).
Yusuf et al. (2021)	Fuel additives review, diesel engines	Positive effect on performance, reduced emissions (Yusuf et al., 2022).
Aprianto & Irawan (2021)	EP and ER additives, SFC measurement	Reduced specific fuel consumption (Ananda, 2025).
Daud et al. (2022)	Fuel additives review, ICE performance	Alcohol, hydrogen, metal oxide additives improve performance

Source: Research Data

Although many previous studies have investigated the effects of fuel additives on gasoline engine performance, most have focused only on a single additive type or a single fuel variation. In addition, the evaluated parameters have generally been limited to power output, fuel consumption, or exhaust emissions separately. Comprehensive investigations involving torque, effective power, hourly fuel consumption, specific fuel consumption, and thermal efficiency simultaneously remain limited. Furthermore, comparative studies involving commercial additives combined with fuels with different octane ratings are still relatively scarce, particularly for modern automatic motorcycles such as the Honda Scoopy 110 cc engine.

Another limitation found in previous studies is the lack of investigation into the optimum concentration of additive mixtures under identical operating conditions. Most studies have evaluated only one or two additive concentrations, making it difficult to identify the most effective additive dosage for improving combustion performance and fuel efficiency. Therefore, further investigation is necessary to comprehensively evaluate the comparative performance of different additive formulations and fuel types.

Based on these considerations, this study investigates the effects of STP Octane Booster and Nitro Race additives mixed with Pertalite and Pertamax Turbo fuels on the performance characteristics of a Honda Scoopy 110 cc engine. The evaluated parameters include engine torque, effective power, hourly fuel consumption, specific fuel consumption (SFC), and thermal efficiency under several engine-speed variations.

The novelty of this study lies in the comparative evaluation of two commercial fuel additives combined with two gasoline fuels with different octane ratings under identical experimental conditions. Unlike previous studies, this research provides a more comprehensive performance analysis by simultaneously evaluating torque, power output, fuel consumption, specific fuel consumption, and thermal efficiency using multiple additive concentration levels. This study also aims to identify the optimum additive–fuel combination capable of improving combustion performance and fuel efficiency in a modern automatic motorcycle engine.

METHOD

Research Design

This study employed a quantitative experimental method to investigate the effects of fuel additives on the engine performance and fuel efficiency of a Honda Scoopy 110 cc spark-ignition engine. The experimental approach was selected because it allowed direct observation and measurement of engine performance parameters under controlled operating conditions (Heywood, 2018; Khedr et al., 2025). The research focused on evaluating the influence of two commercial fuel additives, namely STP Octane Booster and Nitro Race, when mixed with two different gasoline fuels, namely Pertalite and Pertamax Turbo. The experiment was conducted using several additive concentration variations to determine the most effective fuel–additive combination for improving engine performance and combustion efficiency. The measured parameters included engine torque, brake power, hourly fuel consumption, specific fuel consumption (SFC), and thermal efficiency.

Research Object and Materials

The object used in this study was a 2022 Honda Scoopy motorcycle equipped with a 110 cc four-stroke, single-cylinder, spark-ignition engine. The engine specifications are presented in Table 2.

Table 2. Specifications of Honda Scoopy 110 CC Engine

Parameter	Specification
Engine type	4-stroke, SOHC
Cooling system	Air cooled
Cylinder volume	110 cc
Fuel system	PGM-FI
Transmission	Automatic
Fuel type	Gasoline

Source: Research Data

The fuels used in this study consisted of (1) Pertalite gasoline fuel (RON 90, density: 0.715 kg/L) and (2) Pertamax Turbo gasoline fuel (RON 98, density: 0.723 kg/L). Two commercial fuel additives were used: (1) STP Octane Booster, an MMT-based octane enhancer, and (2) Nitro Race additive, an aniline-based aromatic amine octane booster. The additive concentration variations used in this experiment were 5 mL/L, 10 mL/L, 15 mL/L, 20 mL/L, and 25 mL/L.

Experimental Equipment

The equipment used during the experiment included a chassis dynamometer, tachometer, measuring cylinder, stopwatch, digital scale, fuel measuring cup, thermometer, and standard workshop tools. The chassis dynamometer was used to measure engine torque and effective power at different engine speeds. Fuel consumption measurements were conducted using a volumetric fuel measurement method under steady-state operating conditions.

Experimental Procedure

Before testing, the motorcycle engine was inspected to ensure that it was in proper operating condition. Engine oil, spark plug condition, tire pressure, and the fuel injection system were checked to minimize experimental error. The engine was then warmed up for approximately 10 minutes to achieve a stable operating temperature before data collection.

The experimental procedure was conducted as follows: (1) the fuel tank was drained and filled with the selected fuel mixture; (2) the fuel additives were mixed with gasoline according to the predetermined concentration variations; (3) the motorcycle was operated on a chassis dynamometer; (4) engine performance testing was carried out at engine speeds of 3,000 rpm, 4,000 rpm, and 5,000 rpm; (5) torque and effective power data were recorded directly from the dynamometer; (6) fuel consumption was measured based on the volume of fuel consumed over a specified operating time; and (7) each experiment was repeated three times to improve data reliability, and the average value was used for analysis. To maintain testing consistency, all experiments were performed under similar environmental and operating conditions. The ambient temperature during all tests was maintained between 28°C and 32°C, and the engine temperature was monitored to ensure stable operating conditions before data acquisition. The testing sequence was randomized to minimize systematic bias.

Data Analysis

The experimental data obtained from the dynamometer and fuel consumption measurements were analyzed using engineering performance equations. Engine torque and effective power were evaluated to determine the effect of additive concentration on engine output performance. Effective power was calculated using the following equation: $P = \tau \times \omega$, where P = effective power (W), τ = torque (N·m), and ω = angular velocity (rad/s). If expressed in horsepower, the calculated power in watts was converted using 1 HP = 745.7 W. Specific fuel consumption (SFC) was calculated using the following equation: $SFC = (\dot{m}f \times 3600) / Ne$, where SFC = specific fuel consumption (kg/kWh), $\dot{m}f$ = fuel mass flow rate (kg/s), and Ne = effective power (kW). Thermal efficiency was determined using the following equation: $\eta th = [Ne / (\dot{m}f \times LHV)] \times 100\%$, where ηth = thermal efficiency (%), Ne = effective power (kW), $\dot{m}f$ = fuel mass flow rate (kg/s), and LHV = lower heating value of the fuel (kJ/kg).

The obtained data were presented in the form of tables and graphs to facilitate comparative analysis between fuel types and additive variations. The results were then interpreted descriptively to identify the optimum additive concentration and fuel combination for improving engine performance and fuel efficiency. Additionally, one-way ANOVA was performed using Microsoft Excel 2021 to determine statistically significant differences ($p < 0.05$) among treatment groups. Data processing and graph generation were also conducted using Microsoft Excel 2021.

RESULTS AND DISCUSSION

Torque Characteristics

Torque of STP Octane Booster Additive Mixture and Pertalite Fuel

The torque of the STP Octane Booster additive mixture and Pertalite fuel is in table 3.

Table 3. Torque of STP Octane Booster Additive Mixture and Pertalite Fuel

Speed	Mixture of STP Octane Booster Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	3.12	4.13	5.08	5.85	6.21
4000	3.52	4.38	5.21	5.97	6.37
5000	4.73	5.69	6.98	7.28	7.93

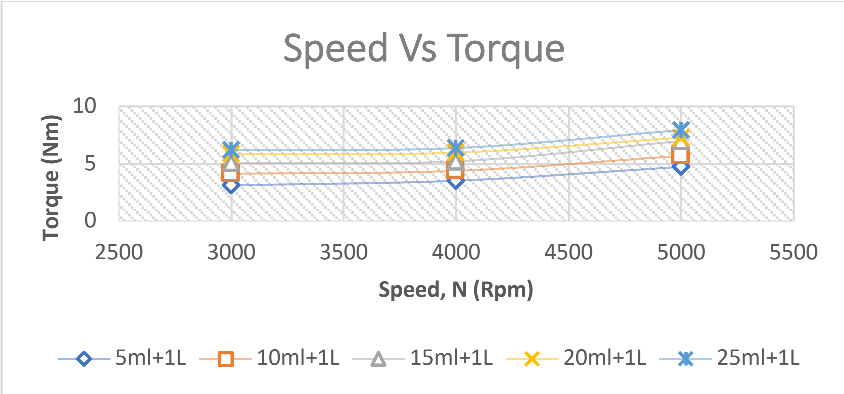

Figure 1. Graph of Torque versus STP Octane Booster Additive and Pertalite Fuel

Based on Table 3 and Figure 1, the torque value increased with the addition of STP Octane Booster to Pertalite fuel at all engine speed variations. The highest torque was obtained at an additive concentration of 25 ml/L and an engine speed of 5,000 rpm. This indicates that the addition of the octane booster improved combustion stability and increased combustion pressure inside the cylinder, resulting in a higher engine torque output. The increase in torque was associated with improved fuel combustion quality due to the higher octane characteristics of the fuel mixture. Better combustion promoted more complete fuel burning and improved pressure distribution during the power stroke (Heywood, 2018; Khedr et al., 2025). Higher-octane fuel improves combustion stability and reduces the tendency for knocking, thereby increasing engine torque and effective power (Mohan et al., 2024; Stone, 1999). In addition, higher additive concentrations contributed to more stable flame propagation, thereby improving effective engine performance.

Torque of Nitro Race Additive Mixture and Pertalite Fuel

The torque of the Nitro Race additive mixture and Pertalite fuel shown in table 4.

Table 4. Torque of Nitro Race Additive Mixture and Pertalite Fuel

Speed	Mixture of Nitro Race Additive in Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	3.1	4.11	5.06	5.82	6.19
4000	3.49	4.35	5.19	5.95	6.35
5000	4.69	5.65	6.96	7.22	7.91

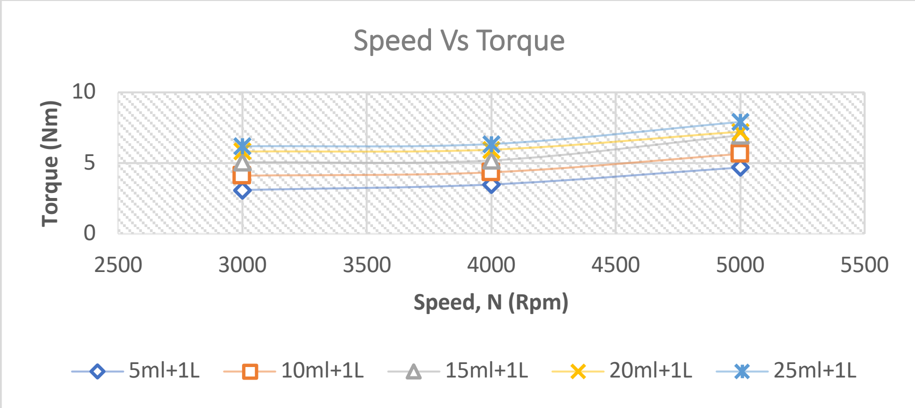

Figure 2. Graph of Torque versus Nitro Race Additive Mixture and Pertalite Fuel

Based on Table 4 and Figure 2, the addition of the Nitro Race additive to Pertalite fuel also increased engine torque across all engine speed variations. The highest torque value was observed at the highest additive concentration, 25 mL/L. This result indicates that the Nitro Race additive improved combustion characteristics and increased combustion effectiveness. Compared with STP Octane Booster, the torque increase produced by the Nitro Race additive was slightly lower. This condition may be related to differences in chemical composition and octane-enhancing capability between the two additives. STP Octane Booster likely provided better resistance to premature combustion and more stable ignition timing, resulting in higher torque output. This condition occurred because improved combustion stability increased cylinder pressure and enhanced the efficiency of mechanical energy conversion (Heywood, 2018; Khedr et al., 2025; Stone, 1999).

Torque of STP Octane Booster Additive Mixture and Pertamax Turbo Fuel

The torque of the STP Octane Booster additive mixture in Pertamax Turbo fuel shown in table 5.

Table 5. Torque of STP Octane Booster Additive Mixture and Pertamax Turbo Fuel

Speed	Mixture of STP Octane Booster Additive in Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	3.23	4.16	5.13	5.89	6.27
4000	3.55	4.41	5.25	6.13	6.43
5000	4.77	5.72	7.23	7.23	7.98

Source: Research Data

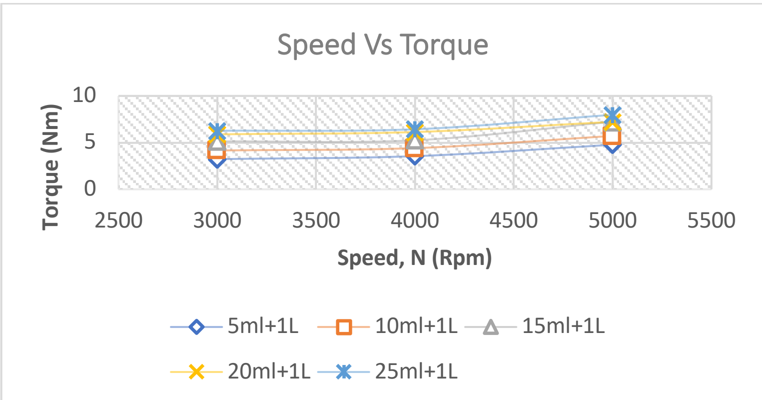

Figure 3. Gaph of Torque versus Nitro Race Additive Mixture and Pertamax Turbo Fuel

Based on Table 5 and Figure 3, the addition of the Nitro Race additive to Pertalite fuel also increased engine torque at all engine speed variations. The highest torque value was observed at the highest additive concentration, 25 mL/L. This result indicates that the Nitro Race additive improved combustion characteristics and increased combustion effectiveness. Compared with STP Octane Booster, the torque increase produced by the Nitro Race additive was slightly lower. This condition may be related to differences in chemical composition and octane-enhancement capability between the two additives. STP Octane Booster likely provided better resistance to premature combustion and more stable ignition timing, leading to higher torque output. This condition occurred because improved combustion stability increased cylinder pressure and enhanced the efficiency of mechanical energy conversion (Heywood, 2018; Khedr et al., 2025; Stone, 1999).

Torque of Nitro Race Additive Mixture and Pertamax Turbo Fuel

The torque of the Nitro Race additive mixture and Pertamax Turbo fuel shown table 6.

Table 6. Torque of Nitro Race Additive Mixture and Pertamax Turbo Fuel

Speed	Mixture of Nitro Race Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	3.20	4.15	5.10	5.87	6.24
4000	3.53	4.39	5.23	5.99	6.39
5000	4.75	5.70	7.17	7.30	7.95

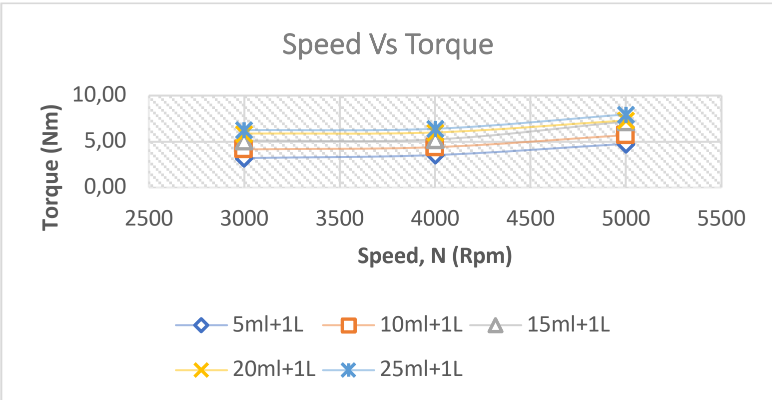

Figure 4. Graph ofTorque versus Nitro Race Additive Mixture and Pertamax Turbo Fuel

Based on Table 6 and Figure 4, the addition of the Nitro Race additive to Pertamax Turbo fuel also significantly increased engine torque. The highest torque value was achieved at an additive concentration of 25 mL/L and an engine speed of 5,000 rpm. Several fluctuations observed under medium engine-speed conditions may have been caused by variations in combustion stability and engine thermal conditions during repeated experiments. However, the overall trend still demonstrates that higher additive concentrations improved engine torque performance. Similar results were reported by Mohan et al. (2024), who found that fuel additives improved combustion pressure and torque characteristics in spark-ignition engines.

Effective Power Characteristics

Power of STP Octane Booster Additive Mixture and Pertalite Fuel

The recap of power results for the STP Octane Booster additive mixture in Pertalite fuel, with additive quantities of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml per 1 liter of Pertalite, shown in table 7.

Table 7. Recapitulation of Power Results for STP Octane Booster Additive Mixture and Pertalite Fuel

Speed	Mixture of STP Octane Booster Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.9797	1.2968	1.5951	1.8369	1.9499
4000	1.4737	1.8338	2.1813	2.4994	2.6669
5000	2.4774	2.9775	3.6507	3.8077	4.1507

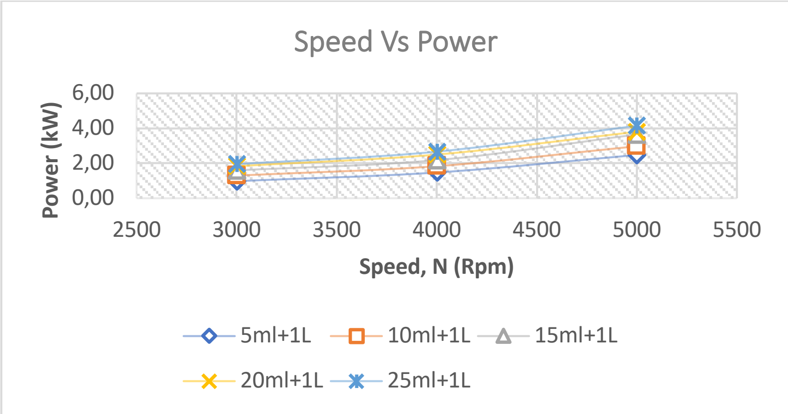

Figure 5. Graph of Power engine versus STP Octane Booster Additive Mixture in Pertalite Fuel

Table 7 and Figure 5 indicate that brake power increased with engine speed and additive concentration. The highest brake power was obtained at 5,000 rpm with an additive concentration of 25 mL/L. This increase occurred because higher torque values directly contributed to increased brake power output, as described by standard engine power equations. Improved combustion efficiency and better fuel-burning quality enabled the engine to convert chemical energy into mechanical work more effectively (Heywood, 2018; Khedr et al., 2025; Stone, 1999).

Power of Nitro Race Additive Mixture and Pertalite Fuel

The recap of power results for the Nitro Race additive mixture and Pertalite fuel, with additive quantities of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml per 1 liter of Pertalite, shown in table 8.

Table 8. Recapitulation of the Performance Results of the STP Octane Booster Additive and Pertalite Fuel

Speed	Mixture of STP Octane Booster Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.9734	1.2905	1.5888	1.8275	1.9437
4000	1.4611	1.8212	2.1729	2.4911	2.6585
5000	2.4544	2.9568	3.6424	3.7942	4.1396

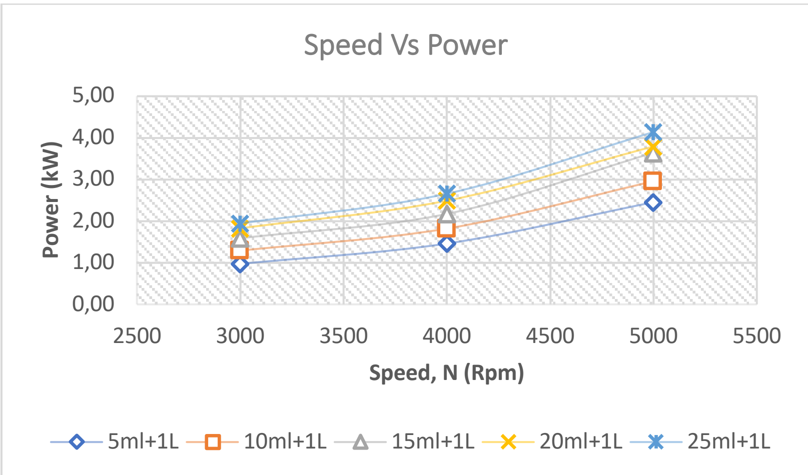

Figure 6. Graph of Power engine versus Nitro Race Additive Mixture and Pertalite Fuel

Based on Table 8 and Figure 6, the Nitro Race additive also increased effective engine power across all engine speed variations. However, the resulting power values remained slightly lower than those produced by STP Octane Booster. This difference suggests that the combustion-enhancing capability of STP Octane Booster was more effective in improving cylinder pressure and engine work output. Similar observations were reported by Elfasakhany (2016), who stated that fuel additives significantly affect combustion quality and engine performance (El-Adawy et al., 2026).

Power of STP Octane Booster Additive Mixture and Pertamax Turbo Fuel

The recap of power results for the STP Octane Booster additive mixture and Pertamax Turbo fuel, with additive quantities of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml per 1 liter of Pertamax Turbo, shown table 9.

Table 9. Recapitulation of the Performance Results of the STP Octane Booster Additive in Pertalite Fuel

Speed	Mixture of STP Octane Booster Additive in Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	1.0142	1.3062	1.6108	1.8495	1.9688
4000	1.4863	1.8463	2.1980	2.5664	2.6920
5000	2.4963	2.9935	3.7837	3.8308	4.1762

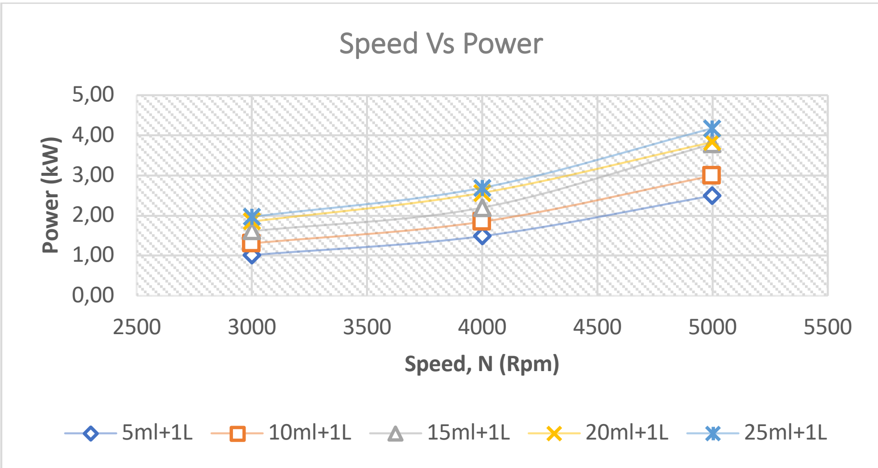

Figure 7. Graph of Power engine versus STP Octane Booster Additive Mixture and Pertamax Turbo Fuel

The results in Table 9 and Figure 7 show that the combination of STP Octane Booster and Pertamax Turbo produced the highest effective power among all tested fuel mixtures. The increase in effective power was strongly influenced by improved combustion quality and the higher octane rating of the fuel mixture. At higher engine speeds, combustion became more efficient because of improved flame propagation and reduced combustion instability. This condition enabled the engine to generate a consistently higher power output (Mohan et al., 2024; Stone, 1999).

Power of Nitro Race Additive Mixture and Pertamax Turbo Fuel

The recap of power results for the Nitro Race additive mixture in Pertamax Turbo fuel, with additive quantities of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml per 1 liter of Pertamax Turbo, is shown in table 10.

Table 10. Recapitulation of Power Results for Nitro Race Additive Mixture and Pertamax Turbo Fuel

Speed	Mixture of Nitro Race Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	1.0048	1.3031	1.6014	1.8432	1.9594
4000	1.4779	1.8379	2.1896	2.5078	2.6753
5000	2.4858	2.9830	3.7523	3.8203	4.1605

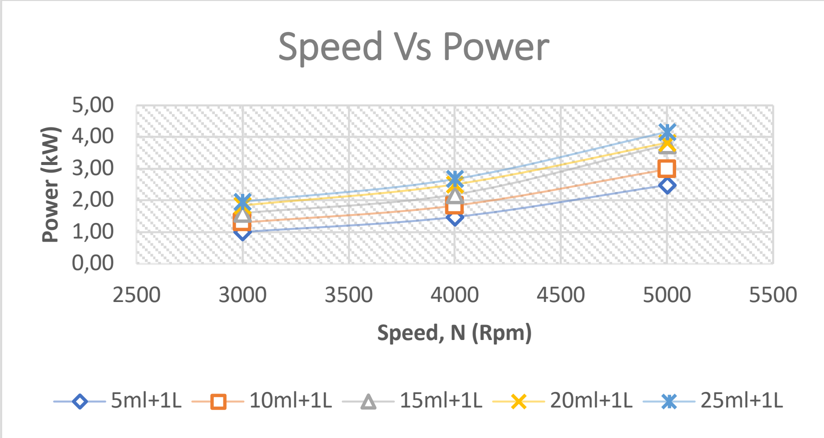

Figure 8. Graph of Power engine versus Nitro Race Additive Mixture and Pertamax Turbo Fuel

Based on Table 10 and Figure 8, effective power increased with engine speed and additive concentration. The Nitro Race additive improved combustion quality sufficiently to increase engine output power, although its performance remained slightly below that of the STP Octane Booster mixture. This result confirms that additive composition significantly influences combustion efficiency and engine performance characteristics (Agarwal, 2007; Vinothkumar et al., 2026).

Hourly Fuel Consumption Characteristics

Each additive is used in quantities of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml, with 1 liter of fuel. The density of Pertalite fuel is 0.715 kg/m^3, while the density of Pertamax Turbo fuel is 0.723 kg/m^3.

Fuel Consumption Per Hour for STP Octane Booster Additive Mixture and Pertalite Fuel

Recapitulation of fuel consumption results for the STP Octane Booster additive mixture of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml in 1 liter of Pertalite is shown in table 11.

Table 11. Recapitulation of Fuel Consumption for STP Octane Booster Additive Mixture and Pertalite Fuel

Speed	Mixture of STP Octane Booster Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.6990	0.6670	0.6370	0.5830	0.4980
4000	0.7610	0.7220	0.6880	0.6400	0.5380
5000	0.8920	0.8390	0.7680	0.7290	0.6140

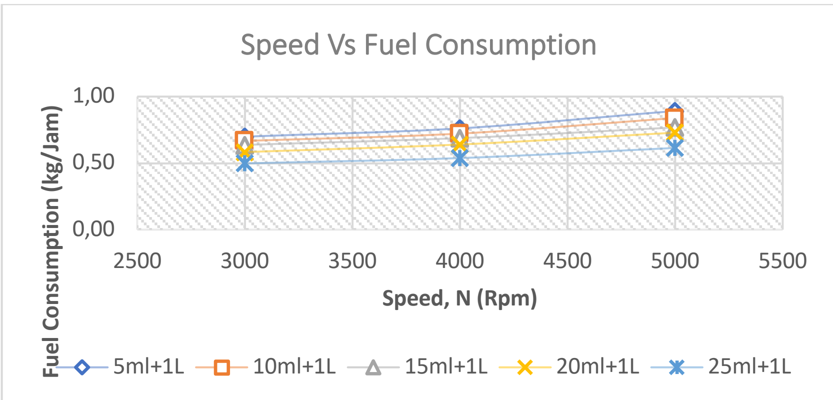

Figure 9. Graph of Fuel Consumption for STP Octane Booster Additive Mixture and Pertalite Fuel

The results in Table 11 and Figure 9 indicate that hourly fuel consumption increased with engine speed. However, the addition of STP Octane Booster reduced hourly fuel consumption compared with lower additive concentrations. Improved combustion completeness contributed to lower fuel consumption and reduced specific fuel consumption values (Elfasakhany & Mahrous, 2016; Yusuf et al., 2022; Yusuf & Inambao, 2021). Fuel additives improved combustion effectiveness, enabling the engine to produce greater output power with lower fuel consumption (Agarwal, 2007; Vinothkumar et al., 2026).

Fuel Consumption per Hour for Nitro Race Additive Mixture and Pertalite Fuel

Recapitulation of fuel consumption results for the Nitro Race additive mixture of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml in 1 liter of Pertalite is presented in table 12.

Table 12. Recapitulation of Fuel Consumption for Nitro Race Additive Mixture and Pertalite

Speed	Mixture of Nitro Race Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.7190	0.6840	0.6530	0.5970	0.5070
4000	0.7840	0.7430	0.7060	0.6560	0.5500
5000	0.9240	0.8670	0.7920	0.7500	0.6280

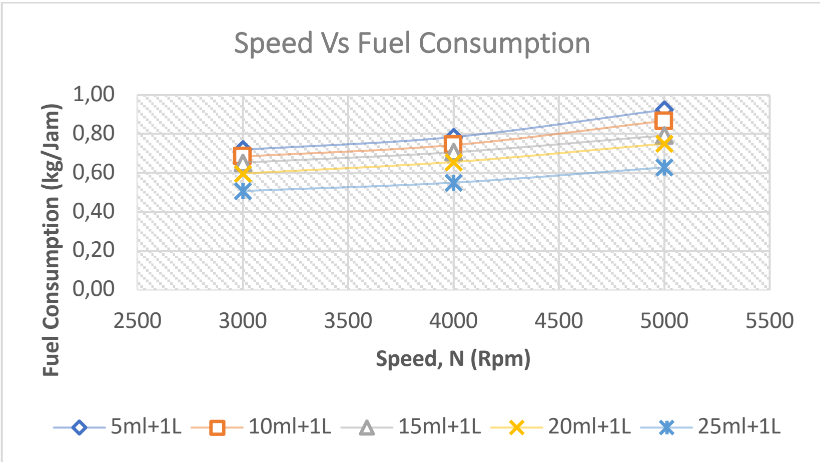

Figure 10. Graph of Fuel Consumption for the Nitro Race Additive Mixture and Pertalite

Based on Table 12 and Figure 10, the Nitro Race additive also reduced fuel consumption compared with lower additive concentrations. However, the reduction was not as significant as that achieved with the STP Octane Booster mixture. This result suggests that the STP Octane Booster provided better combustion optimization and improved thermal conversion efficiency more effectively than the Nitro Race additive (El-Adawy et al., 2026; Elfasakhany & Mahrous, 2016).

Fuel Consumption per Hour for the STP Octane Booster Additive Mixture and Pertamax Turbo Fuel

Recapitulation of fuel consumption results for the STP Octane Booster additive mixture of 5 ml, 10 ml, 15 ml, 20 ml, and 25 ml in 1 liter of Pertamax Turbo is shown in table 13.

Table 13. Recapitulation of Fuel Consumption for the STP Octane Booster Additive Mixture and Pertamax Turbo

Speed	Mixture of STP Octane Booster Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.5570	0.5360	0.5180	0.5010	0.4450
4000	0.6080	0.5840	0.5620	0.5420	0.5130
5000	0.7470	0.6920	0.6600	0.6320	0.5560

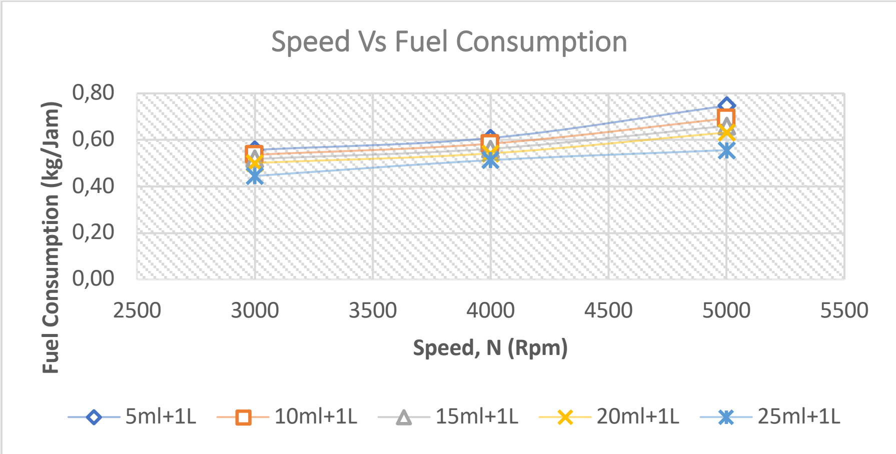

Figure 11. Graph of Fuel Consumption for the STP Octane Booster Additive Mixture and Pertamax Turbo

Table 13 and Figure 11 show that the combination of STP Octane Booster and Pertamax Turbo produced the lowest hourly fuel consumption among all tested fuel mixtures. This finding demonstrates that high-octane fuel combined with combustion-enhancing additives improved combustion completeness and minimized fuel losses during engine operation (Yusuf et al., 2022; Yusuf & Inambao, 2021).

Fuel Consumption Per Hour for Nitro Race Additive Mixture and Pertamax Turbo Fuel

Recapitulation of fuel consumption results for the Nitro Race additive mixture in Pertamax Turbo, with a total of 1 liter, is presented in table 14.

Table 14. Recapitulation of Fuel Consumption for Nitro Race Additive Mixture and Pertamax Turbo

Speed	Mixture of Nitro Race Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.5810	0.5590	0.5390	0.5210	0.4680
4000	0.6380	0.6110	0.5870	0.5650	0.5340
5000	0.7690	0.7300	0.6950	0.6640	0.5800

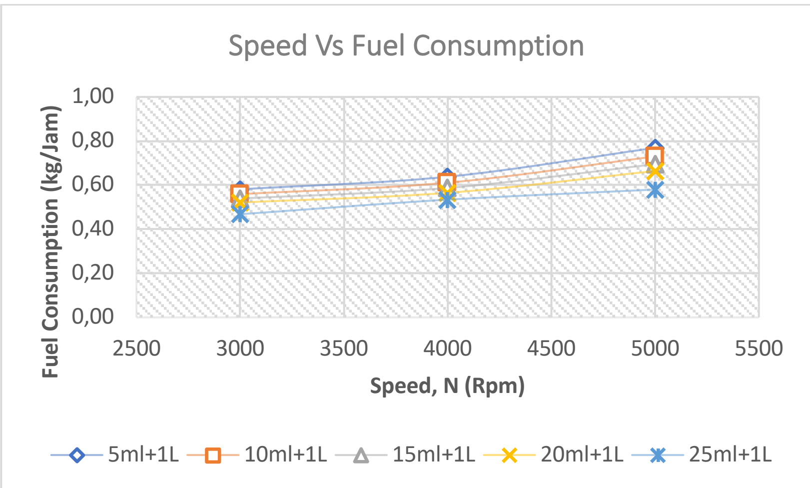

Figure 12. Graph of Fuel Consumption for the Nitro Race Additive Mixture and Pertamax Turbo

Based on Table 14 and Figure 12, the addition of the Nitro Race additive reduced fuel consumption at all engine speeds. However, the resulting fuel efficiency remained slightly lower than that achieved with the STP Octane Booster mixture. This lower efficiency may have been caused by a less effective combustion-enhancement capability and lower resistance to combustion instability (Agarwal, 2007; Vinothkumar et al., 2026).

Specific Fuel Consumption Characteristics

Specific Fuel Consumption for the Mixture of STP Octane Booster Additive in Pertalite Fuel

Recapitulation of specific fuel consumption (SFC) results for the mixture of STP Octane Booster additive in 1 liter of Pertalite fuel is presented in table 15.

Table 15. Recapitulation of Specific Fuel Consumption for the Mixture of STP Octane Booster Additive and Pertalite

Speed	Mixture of STP Octane Booster Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.7130	0.5140	0.3990	0.3180	0.2550
4000	0.5160	0.3940	0.3150	0.2560	0.2020
5000	0.3600	0.2820	0.2100	0.1920	0.1480

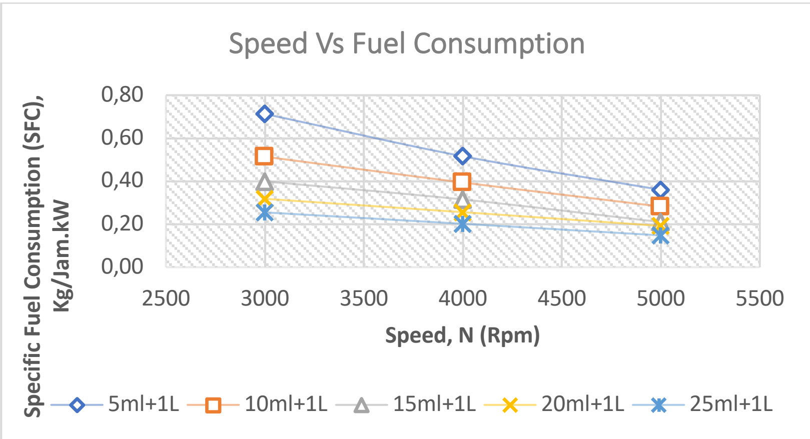

Figure 13. Graph of Specific Fuel Consumption for the Mixture of STP Octane Booster Additive and Pertalite

Specific Fuel Consumption for Nitro Race Additive Mixture in Pertalite Fuel

Recapitulation of specific fuel consumption (SFC) for the Nitro Race additive mixture in 1 liter of Pertalite fuel is presented in the table 16.

Table 16. Recapitulation of Specific Fuel Consumption for Nitro Race Additive Mixture and Pertalite.

Speed	Mixture of Nitro Race Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.7380	0.5300	0.4110	0.3270	0.2610
4000	0.5370	0.4080	0.3250	0.2630	0.2070
5000	0.3760	0.2930	0.2170	0.1980	0.1520

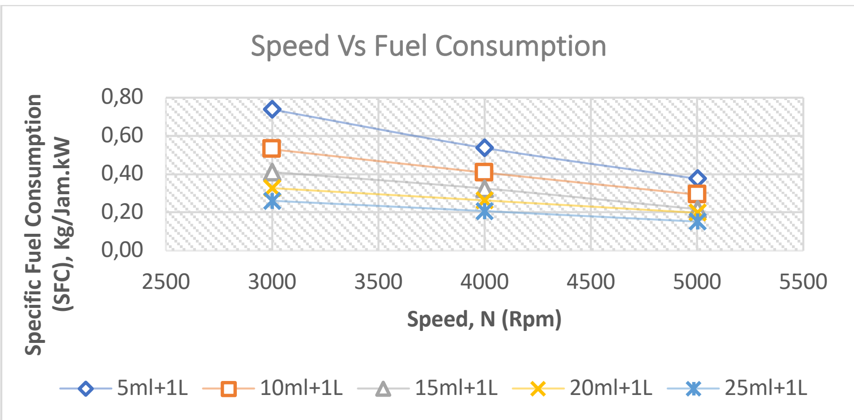

Figure 14. Graph of Specific Fuel Consumption for Nitro Race Additive Mixture and Pertalite

Specific Fuel Consumption for STP Octane Booster Additive Mixture in Pertamax Turbo Fuel

Recapitulation of specific fuel consumption (SFC) results for the STP Octane Booster additive mixture in 1 liter of Pertamax Turbo fuel is presented in table 17.

Table 17. Recapitulation of Specific Fuel Consumption for STP Octane Booster Additive Mixture and Pertamax Turbo Fuel.

Speed	Mixture of STP Octane Booster Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.5490	0.4110	0.3220	0.2710	0.2260
4000	0.4090	0.3160	0.2560	0.2110	0.1910
5000	0.2990	0.2310	0.1750	0.1650	0.1330

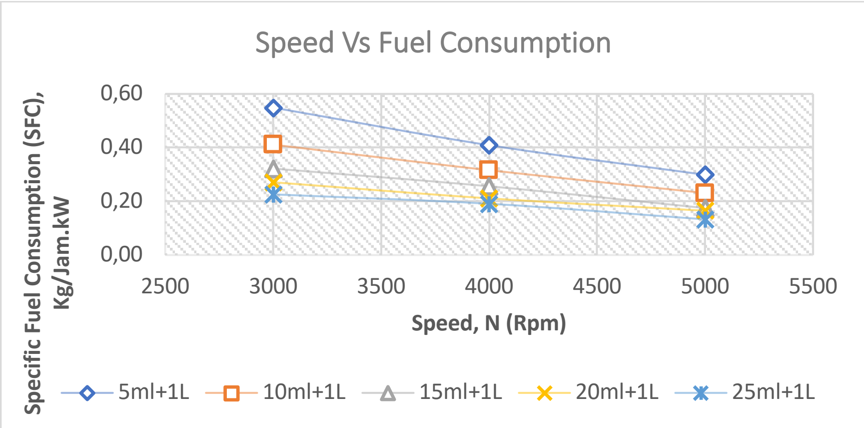

Figure 15. Graph of Specific Fuel Consumption for STP Octane Booster Additive Mixture and Pertamax Turbo Fuel

Specific Fuel Consumption for Nitro Race Additive Mixture and Pertamax Turbo Fuel

Recapitulation of specific fuel consumption (SFC) results for the Nitro Race additive mixture in 1 liter of Pertamax Turbo fuel is presented in table 18.

Table 18. Recapitulation of Specific Fuel Consumption for Nitro Race Additive Mixture and Pertamax Turbo Fuel

Speed	Mixture of Nitro Race Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	0.5790	0.4290	0.3370	0.2820	0.2390
4000	0.4320	0.3330	0.2680	0.2250	0.1990
5000	0.3090	0.2450	0.1850	0.1740	0.1390

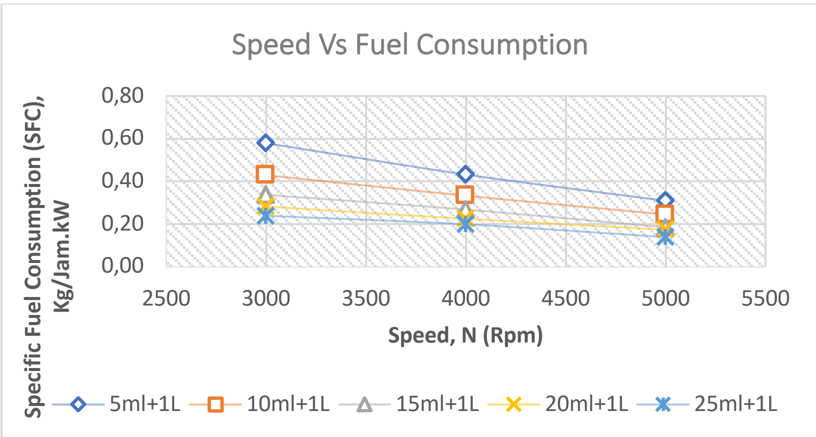

Figure 16. Graph of Specific Fuel Consumption for Nitro Race Additive Mixture and Pertamax Turbo Fuel

The results presented in Tables 15–18 and Figures 13–16 show that specific fuel consumption decreased as the additive concentration increased. Lower SFC values indicate better fuel efficiency because less fuel is required to produce the same engine power output. Among all tested fuel mixtures, STP Octane Booster combined with Pertamax Turbo produced the lowest SFC values. This result indicates superior combustion efficiency and improved energy conversion capability. Improved combustion completeness contributed to lower fuel consumption and reduced specific fuel consumption values (Elfasakhany & Mahrous, 2016; Yusuf et al., 2022; Yusuf & Inambao, 2021).

Thermal Efficiency Characteristics

Effective Thermal Efficiency for the Mixture of STP Octane Booster Additive and Pertalite Fuel

Recapitulation of the effective thermal efficiency results for the mixture of STP Octane Booster additive in 1 liter of Pertalite fuel is presented in the table 19.

Table 19. Recapitulation of Effective Thermal Efficiency for the Mixture of STP Octane Booster Additive and Pertalite

Speed	Mixture of STP Octane Booster Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	11	16	20	26	32
4000	16	21	26	32	40
5000	23	29	39	42	55

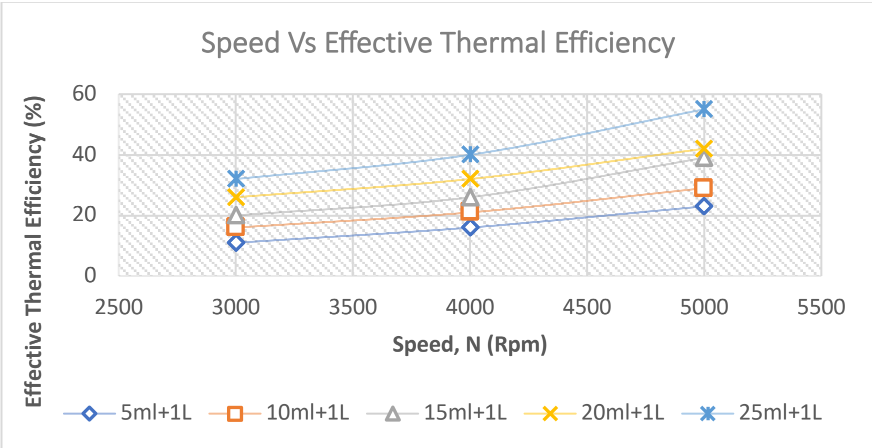

Figure 17. Graph of Effective Thermal Efficiency for the Mixture of STP Octane Booster Additive and Pertalite

Based on Table 19 and Figure 17, thermal efficiency increased with additive concentration and engine speed. Improved combustion quality enabled more fuel energy to be converted into useful mechanical work. Better flame propagation and combustion efficiency enhanced the conversion of thermal energy into mechanical work (Ansari et al., 2025; Ganesan, 2022; Koç et al., 2009). However, the reported thermal efficiency values above 60% are relatively high for a small spark-ignition motorcycle engine. Typical brake thermal efficiency values for small spark-ignition engines generally range from 25% to 38%, depending on engine operating conditions (Gupta, 2025; Heywood, 2018; Khedr et al., 2025; Pulkrabek, 2004).

Effective Thermal Efficiency for the Mixture of Nitro Race Additive and Pertalite Fuel

Recapitulation of effective thermal efficiency results for the mixture of Nitro Race additive in 1 liter of Pertalite fuel is presented in the table 20.

Table 20. Recapitulation of Effective Thermal Efficiency for the Mixture of Nitro Race Additive and Pertalite

Speed	Mixture of Nitro Race Additive and Pertalite Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	11	15	20	25	31
4000	15	20	25	31	39
5000	22	28	37	41	54

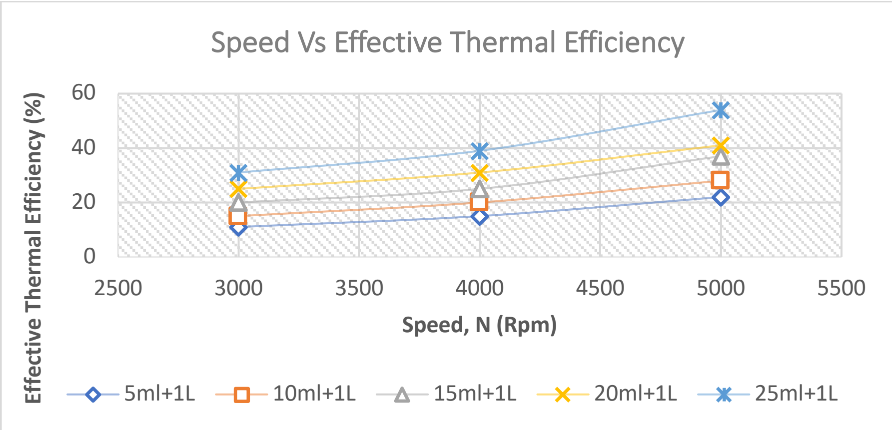

Figure 18. Graph of Effective Thermal Efficiency for the Pertalite Fuel Mixed with Nitro Race Additive

Table 20 and Figure 18 show that thermal efficiency increased with additive concentration and engine speed. The Nitro Race additive improved combustion characteristics and reduced losses from incomplete combustion. Improved flame propagation and combustion efficiency increase the conversion of thermal energy into mechanical work (Ansari et al., 2025; Koç et al., 2009).

Effective Thermal Efficiency for the Mixture of STP Octane Booster Additive and Pertamax Turbo Fuel

Recapitulation of effective thermal efficiency results for the mixture of STP Octane Booster additive in 1 liter of Pertamax Turbo fuel is presented in the table 21.

Table 21. Recapitulation of Effective Thermal Efficiency for the Mixture of STP Octane Booster Additive and Pertamax Turbo Fuel.

Speed	Mixture of STP Octane Booster Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	15	20	25	30	36
4000	20	25	31	38	42
5000	27	35	46	49	60

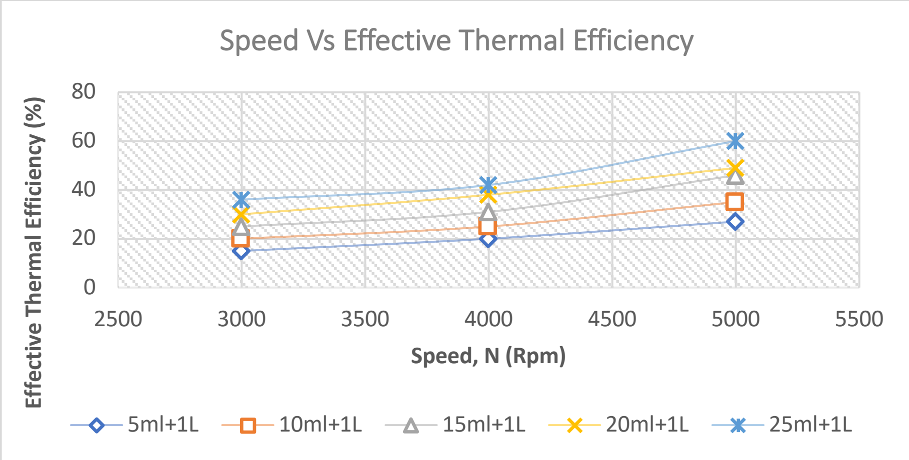

Figure 19. Graph of Effective Thermal Efficiency for the Pertamax Turbo Fuel Mixed with STP Octane Booster Additive

Based on Table 21 and Figure 19, the combination of STP Octane Booster and Pertamax Turbo produced the highest thermal efficiency values among all tested fuel mixtures. The higher octane rating and improved combustion stability contributed to better thermal energy conversion into mechanical power (Ganesan, 2022; Stone, 1999).

Effective Thermal Efficiency for the Mixture of Nitro Race Additive and Pertamax Turbo Fuel

Recapitulation of effective thermal efficiency results for the mixture of Nitro Race additive in 1 liter of Pertamax Turbo fuel is presented in the table 22.

Table 22. Recapitulation of Effective Thermal Efficiency for the Mixture of Nitro Race Additive and Pertamax Turbo.

Speed	Mixture of Nitro Race Additive and Pertamax Turbo Fuel				
	5 ml + 1 L	10 ml + 1 L	15 ml +1 L	20 ml + 1 L	25 ml + 1 L
3000	14	19	24	28	34
4000	19	24	30	36	40
5000	26	33	43	46	58

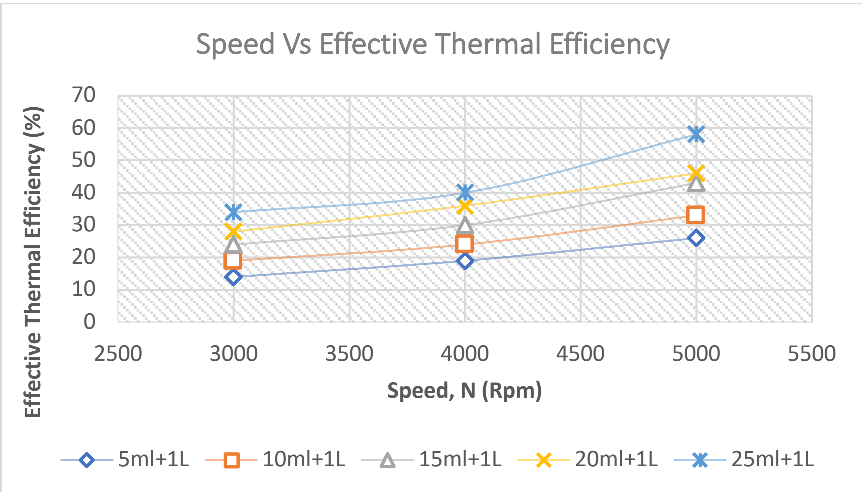

Figure 20. Graph of Effective Thermal Efficiency of Pertamax Turbo Fuel with Nitro Race Additive

Table 22 and Figure 20 indicate that the Nitro Race additive improved thermal efficiency at all engine speeds and additive concentrations. The increase in thermal efficiency demonstrates that additive utilization contributed positively to combustion effectiveness. Although the efficiency values remained slightly lower than those of the STP Octane Booster mixture, the results consistently show that fuel additives can improve fuel combustion quality and engine operating efficiency (Elfasakhany & Mahrous, 2016; Mohan et al., 2024). Overall, the experimental results demonstrate that STP Octane Booster mixed with Pertamax Turbo provided the best engine performance and fuel efficiency among all tested fuel combinations. This combination produced the highest torque and effective power, as well as the lowest fuel consumption and specific fuel consumption values. The findings indicate that higher-octane fuel combined with combustion-enhancing additives can significantly improve combustion quality and engine performance characteristics in small spark-ignition motorcycle engines.

Discussion

The enhancement in torque and power can be attributed to improved combustion quality resulting from an increase in the fuel octane rating. Higher-octane fuel exhibits greater resistance to premature combustion, enabling a more stable and efficient combustion process and generating higher cylinder pressure during the power stroke.

The superior performance of STP Octane Booster compared with Nitro Race may be associated with differences in their chemical compositions. STP Octane Booster contains octane-enhancing compounds that promote more complete combustion and improve flame propagation characteristics. Consequently, a larger proportion of the fuel's chemical energy is converted into useful mechanical work. Similar findings have been reported by Mohan et al. (2024), who observed that octane-enhancing additives improved combustion stability and engine performance. Likewise, Maridjo and Angga (2019) reported that fuels with higher octane ratings generated greater torque and power in spark-ignition engines (Ananda, 2025).

The reduction in specific fuel consumption indicates improved fuel utilization efficiency. Lower specific fuel consumption values suggest that less fuel is required to produce the same amount of engine power. This improvement is likely attributable to more complete combustion and enhanced energy conversion efficiency within the combustion chamber. The results are consistent with those reported by Aprianto and Irawan (2021), who found that fuel additives reduced fuel consumption through improvements in combustion effectiveness (Ananda, 2025).

The increase in thermal efficiency further supports the argument that fuel additives enhanced the overall combustion process. Improved thermal efficiency indicates that a greater proportion of the fuel's energy content was converted into useful engine output rather than being lost as heat. Similar conclusions were reported by Elfasakhany (2016) and Daud et al. (2022), who emphasized that fuel additives can improve combustion characteristics and overall engine efficiency (El-Adawy et al., 2026). However, the extent of efficiency improvement observed in this study should be interpreted within the specific operating conditions of the tested engine and fuel system.

The identification of an optimum additive concentration suggests that excessive additive dosage may not provide substantial additional benefits and may reduce cost-effectiveness. Therefore, determining the optimal dosage is essential for maximizing performance gains while maintaining economic feasibility.

Compared with previous studies, this research contributes new empirical evidence by simultaneously comparing two commercial fuel additives, namely STP Octane Booster and Nitro Race, across five concentration levels under identical testing conditions. This approach provides a more comprehensive understanding of additive effectiveness and allows a direct evaluation of their relative performance, which has rarely been addressed in previous studies.

CONCLUSION

This study investigated the effects of STP Octane Booster and Nitro Race additives at various concentrations on the performance of a 110 cc four-stroke spark-ignition engine. The results indicate that both additives improved engine performance by increasing torque, power output, and thermal efficiency while reducing specific fuel consumption. These improvements demonstrate that fuel additives can enhance combustion quality and optimize the conversion of fuel energy into useful mechanical output. Among the tested additives, STP Octane Booster generally exhibited greater performance enhancement than Nitro Race across most operating conditions, indicating its higher effectiveness in improving combustion characteristics. The findings also reveal that additive concentration plays an important role in determining performance gains, suggesting the existence of an optimum dosage that maximizes benefits while maintaining fuel economy.

The primary contribution of this study lies in providing a direct comparison between two commercially available fuel additives across multiple concentration levels under identical experimental conditions. The results offer practical insights for vehicle users and automotive practitioners regarding the selection and application of fuel additives to improve engine performance and fuel efficiency. Future studies are recommended to investigate the long-term effects of fuel additive use on engine durability, combustion emissions, and component wear, as well as to validate the findings using different engine displacements, fuel types, and operating conditions.

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AUTHOR CONTRIBUTION STATEMENT

Darmuli: Conceptualization, methodology, investigation, data collection, formal analysis, and writing original draft preparation. Obet Ranteallo: Supervision, validation, data interpretation, editing, and final manuscript approval. All authors have read and approved the final version of the manuscript.

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