Energy, Environment and Storage

Journal Homepage: www.enenstrg.com

Olive Seed Based Biodiesel Production Process and Investigation of Combustion Properties of Fuel Blends With Standard Diesel And TiO_2 and Activated Carbon Nanoparticle Additives in Diesel Engines

Selman Taşdemir[1], Volkan Sabri Kül[2*], Mehmet Saritaş[3], Serhat Bilgin[4]

[1] *Erciyes University Department of Mechanical Engineering, Kayseri, Türkiye, ORCID: 0009-0008-5704-5679*

[2*] *Erciyes University, Graduate School of Natural and Applied Sciences, ORCID: 0000-0002-6412-6062*

[3] *Erciyes University, Department of Mechanical Engineering, Kayseri, Türkiye ORCID: 0000-0001-6576-689X*

[4] *Tokat Gaziosmanpasa University: Tokat, Türkiye ORCID: 0000-0002-6812-6641*

ABSTRACT. In this study, the production stages of biodiesel from olive stones and the equipment used in the production process are introduced. Furthermore, the engine performance and exhaust emissions of biodiesel blends obtained from olive stones (B20D80) and its nanoparticle-added derivatives in diesel engines were evaluated. Using test data provided by the PCS engine test system, experiments were conducted with pure diesel (D100), olive stones (BOS20D80), and various additives containing 50 ppm TiO_2 and 50 ppm activated carbon + 50 ppm TiO_2 . The experiments revealed improvements in the thermal efficiency of the nanoparticle-added pure diesel and BOS20D80 fuels, while relatively higher NO emissions were observed.

Keywords: *olive seeds, biodiesel, diesel engine, TiO_2 , activated carbon, nanoparticles.*

Article History: Received: 30 August 2025; Revised: 24 September 2025; Accepted:29 September 2025; Availableonline: 30 September 2025
Doi: https://doi.org/10.52924/QZPQ2586

1. INTRODUCTION

The ever-increasing demand for energy, the risk of depletion, and the environmental damage caused by fossil fuel resources have made it necessary to turn to alternative energy sources. Today, a large portion of global energy needs are met through fossil fuels, leading to serious problems in terms of environmental pollution, greenhouse gas emissions, and energy security. Furthermore, the limited reserves of these resources directly impact energy costs and increase foreign dependency in national economies.

In this context, biofuels are considered a significant alternative due to their sustainability, renewable nature, and low environmental impact. Biofuels can be obtained from vegetable or animal oils, agricultural waste, and other organic materials. Their compatibility with diesel engines, in particular, makes them suitable for use without requiring additional modifications to engine technology, making them even more attractive.

There are many studies in the literature regarding additives mixed into diesel fuel [1-20]. Sel, 2013 [4] investigated the effects of blending biodiesel and Eurodiesel fuels at different ratios on engine performance and exhaust emissions. As the biodiesel ratio increased, a decrease in engine power and an increase in specific fuel consumption were observed. Additionally, an increase in NOx emissions and a decrease in CO, HC, and soot emissions were observed. In the second stage, nano-hydro borazine additive was added to the fuel blends, and it was reported that this new fuel increased its viscosity but improved engine performance and reduced specific fuel consumption. However, an increase in CO_2 and NOx and a decrease in CO and soot emissions were observed. Hacıkadiroğlu, 2007 [5] tested blends of 100% diesel (D100), 90% diesel - 10% biodiesel (B10), 80% diesel - 20% biodiesel (B20), and 50% diesel - 50% biodiesel (B50) in a four-stroke, air-cooled, single-cylinder diesel engine. Engine speed, internal pressure, exhaust temperature, and emission values were systematically measured, and the consumption time of a specific volume of fuel was calculated. Experimental data revealed that biodiesel addition positively affects emission parameters. Kumar and Kaya, 2006 [6] produced biodiesel from crude and waste vegetable oils using the transesterification method, determining the optimum temperature, appropriate reactants, and purification methods to achieve high-quality biodiesel production. Basic physical properties of the resulting biodiesels, such as viscosity, density, cetane number, and flash point, were characterized. Raheman et al. (2022) [19] stated that the use of cerium oxide solid particulate additives in 20% biodiesel

*volkanskul@gmail.com

blended diesel fuel increased BTE by 7-13.3% compared to pure diesel fuel. Brake specific energy consumption decreased by 6.7-11.7%. Reductions in HC, CO and NOx emissions were reported by 19.4-55.6%, 6.5-52.8% and 23.2-41.5%, respectively. Vellaiyan et al. (2019) [20] used 100 ppm Titanium oxide (TiO2) solid particulate additive in diesel fuel with the addition of 10% water. They reported reductions in NOx, HC, CO and soot emissions by 21%, 40.1%, 21%, 40.1% and 10.7%, respectively, compared to fuel without TiO2 additive. Örs, 2016 [7] investigated the performance and emission effects of biodiesel-butanol blends on a direct-injection diesel engine. Butanol ratios of 5%, 10%, and 15% were used in blends. With 15% butanol addition, significant reductions in NOx and CO emissions were achieved, but an increase in HC emissions was observed. An approximately 10% improvement in specific fuel consumption was also reported. Aydoğan, 2008 [9] produced biodiesel at a laboratory scale using oils from various sources and tested them under different engine speeds and full-load conditions by blending them with diesel in specific ratios. Engine performance was also evaluated, along with NOx, CO, SO_2, and soot emissions. Research was also conducted on methods for reducing NOx emissions in compression-ignition engines. Nişancı, 2007 [9] conducted engine tests by blending biodiesels obtained from different plants (soybean, sunflower, and canola) at various ratios. The mixtures were tested in direct-injection diesel engines, and emissions and performance parameters were analyzed. Kaya, 2010 [10] investigated the effect of injection pressure on engine performance using biodiesel-diesel fuel blends. In experiments conducted with canola-derived biodiesel, CO_2 and NOx increased as the biodiesel ratio increased, while CO, HC, and soot emissions decreased. Specific fuel consumption increased and efficiency decreased at different injection pressures. Ilgazlı, 2010 [11] evaluated the effects of different biodiesel ratios (B20, B50, and B100) on engine performance and emissions in a four-stroke diesel engine with variable compression ratios. During the experiments, engine power, emissions data, and in-cylinder pressure changes were measured. Peker, 2009 [12] produced biodiesel from non-food grade waste olive oil and obtained a product with 97.6% ester content. The density of the product was measured as 878.6 kg/m³, viscosity as 4.82 mm²/s, flash point as 122°C, and water content as 156 mg/kg.

This study aims to produce biofuels from olive seeds, a widely produced resource in Turkey and a high potential waste stream. Olive seeds are a lignocellulosic agricultural waste with a high energy content. This characteristic makes it both an economically valuable biomass source and, if left unused, creates environmental waste. In the study, olive stones were dried, ground into powder, and then oil was obtained through solvent extraction. Acetone was used as the solvent in the extraction process, and parameters such as temperature and time were controlled throughout the experimental process.

The resulting biofuel was subjected to performance tests on a diesel engine test system in the university's engine test laboratory. The tests were conducted under constant torque and speed conditions, and comparatively evaluated not only olive stone biofuel but also safflower oil, waste oil, their 20% blends, and versions containing 50% titanium dioxide and activated carbon. During the tests, parameters such as engine oil temperature, exhaust temperature, inlet and outlet water temperatures, intake air temperature, and fuel temperature were recorded, and performance analyses were conducted for each fuel type.

The environmental impacts of fossil fuel use have highlighted biofuel alternatives for diesel engines. Biodiesels (especially from non-food sources) reduce CO/HC/smoke in most studies, but exhibit complex effects on BTE/BSFC and NOx due to calorific value and fluidity. Metal oxide nanoparticle additives (AlO_3 , TiO_2 , etc.) can reduce BSFC and CO/HC by improving atomization and combustion through oxygen transport and catalytic oxidation in the fuel; however, NOx generally tends to increase [1-3]. This study evaluates olive stone-derived B20 blends (B20D80) and its field-derived TiO_2 /activated carbon-added derivatives against a D100 reference using real-world engine test data.

These comprehensive analyses evaluated the technical applicability, combustion efficiency, and thermal behavior of olive stone-based biofuel in diesel engines. In addition, in the light of the data obtained, the potential of biofuels as an alternative to traditional fossil fuels was examined and their contribution to environmental sustainability was discussed.

2. MATERIALS AND METHODS

2.1 Test Fuels

2.1.1 Diesel

The diesel fuel used in the experiments was commercially available diesel. It was obtained from a local gas station, and its characteristics are presented in **Table 1**.

Table 1. Diesel [13]

Properties	Diesel
Density	820-845 kg/m3
Stoichiometric ratio	14,92 (app.)
Flash point	55 °C
ignition Temperature	Auto-186–230 °C
Higher Heating Value	45.6 MJ/kg
Low heat Value	42.7 MJ/kg
Cetane Number	51
Viscosity	2.0- 4.5 mm^2 /s

2.1.2 Biodiesel

I. General properties of biodiesel and Standards

To determine the suitability of the produced biodiesel as a fuel, its compliance with the European Union's TS EN 14214 standard and the American ASTM D6751 standard must be assessed. These standards define the fundamental physical and chemical properties of biodiesel that directly affect engine performance, safety, and environmental impacts. The literature reports that the vast majority of biodiesel samples derived from olive stones meet the limit values set by these standards for key parameters such as density, viscosity, flash point, cetane number, acid value, and ester content. This suggests that olive stone-based biodiesel could be a suitable and sustainable alternative fuel for diesel engines.

Table 2. General properties of biodiesel obtained from olive seeds

Properties	Typical Value Range
Density (15°C)	860–880 kg/m³ [13]
Viscosity (40°C)	4,2–5,0 mm²/s [6, 9]
Cetane Number	51–56 [14]
Flash Point	120–130 °C [4]
Cloud Point	-2 ila 0 °C [13]
Pour Point	-15 ila -18 °C
Heating value	39.96 Mj/kg [15]

II. Biodiesel production equipment and production stages from olive seeds

Olive Stone

In this study, olive stones, agricultural waste obtained from the olive processing industry, were used as the primary raw material. The stones, procured from local producers, were air-dried under ambient conditions and then dried in a constant-temperature industrial oven to reduce moisture content. This brought the stones into a physical form and low moisture content suitable for pyrolysis, solvent extraction, and transesterification processes.

Fig.1 Olive Seeds

Drying Process

The olive pits were first pretreated using a natural shade drying method, then dried in a constant-temperature industrial oven at 105°C for approximately 24 hours. This process reduced the moisture content of the biomass to below 10%, eliminating moisture that could reduce reaction efficiency in subsequent chemical processes (especially solvent extraction and pyrolysis).

Raw Material Preparation

The dried stones were homogenized using grinders to a particle size of approximately 1–2 mm. This process was performed to increase both solvent extraction efficiency and pyrolysis reaction efficiency by increasing surface area. The resulting powdered samples were stored in airtight containers at room temperature before starting the reactions.

Methanol (CH_3OH)

High-purity methanol (99%) was chosen as the alcohol component in the transesterification reaction. Methanol served as the primary reactant, enabling the conversion of triglyceride-like fats to methyl esters. Methanol's short-chain, polar structure facilitates the high efficiency of the reaction and facilitates the separation of the methyl ester and glycerin phases.

Sodium Hydroxide (NaOH)

Sodium hydroxide (NaOH), used as a base catalyst to form sodium methoxide solution, played an active role in initiating the transesterification reaction. A homogeneous catalyst solution was prepared by mixing it with high-purity methanol at a predetermined ratio before the reaction. The use of this solution accelerates the conversion of oil to methyl ester and helps maintain chemical stability in the reaction medium. Furthermore, NaOH contributed to maintaining chemical stability in the solution throughout the reaction, increased esterification efficiency, and facilitated the effective separation of the glycerin and biodiesel phases. NaOH, preferred due to its low cost, widespread availability, and high catalytic activity, was used as the base catalyst in biodiesel production in this study in accordance with standards.

Acetone (CH_3COCH_3)

In the post-transesterification product purification phase, acetone was used as a solvent to remove methanol, soap residues, and other byproducts remaining in the reaction mixture. Acetone's low boiling point (56°C) allowed for rapid and energy-efficient evaporation. This facilitated easy separation of the solvent from the biodiesel phase, increased fuel purity, and resulted in a product more compliant with TS EN 14214. Evaporation and separation were carried out using a laboratory-grade HAHN SHIN HS-2005V-N vacuum evaporator. This device enabled controlled solvent removal and prevented degradation of the biodiesel composition. Consequently, this step plays a critical role in improving the fuel properties of biodiesel and reducing negative emissions that may occur during combustion.

Density Measuring Device – Krüss Optronic (Germany)

This device was used to determine the density values of biodiesel samples with high precision. This measurement provided a detailed characterization of the fuel's physical properties and played a critical role in assessing its compliance with international fuel standards such as TS EN 14214 and ASTM D6751. Density is one of the key parameters affecting the combustion characteristics, spray behavior, and energy content of biodiesel. Therefore, density measurement is an important assessment step in the quality control process of the resulting biofuel.

Fig. 2 Density Measuring Device – Krüss Optronic (Germany)

The Cloud and Pour Point Device – Normalab NTE-450

was used to determine the low-temperature performance of produced biodiesel samples. Measurements using this device determined the cloud point (Cloud Point) and pour point (Pour Point) temperatures of biodiesel. These two parameters determine the fuel's ability to maintain fluidity at low temperatures and are critical in preventing problems such as freezing, clogging, and interrupted fuel flow in engine systems, especially in winter conditions. The obtained values contributed to the evaluation of biodiesel's suitability for use in cold climates.

Fig. 3 Normalab NTE-450

The Cold Filter Plugging Point Device – Normalab NTL-450

was used to determine the permeability of a biodiesel sample through the filter surface at low temperatures. This test evaluated whether the fuel could flow into the engine system without clogging the filters in cold weather conditions. The CFPP value is a key parameter that directly affects the fuel's fluidity limit and system safety in diesel engines, especially during winter. The test results were considered a key criterion in evaluating the performance of biodiesel for its usability in cold climates.

Fig. 4 Normalab NTL-450

Fuel-Acetone Separator – HAHN SHIN HS-2005V-N

After transesterification and subsequent solvent purification, evaporation was used to remove residual acetone from the biofuel mixture. This process effectively separated the volatile solvent phase from the biofuel, resulting in a biodiesel with higher purity and stable components. The evaporation process is based on the principle of removing acetone, which has a low boiling point, from the environment under controlled temperatures. The resulting fuel, obtained through this method, better complies with TS EN 14214 and ASTM D6751 standards in terms of both chemical purity and performance.

Fig. 5 Fuel-Acetone Separator

Heated Magnetic Stirrer – DLAB MS-H340-S4

A heated magnetic stirrer was used during the transesterification process to maintain a constant temperature and achieve a homogeneous solution. This device facilitated both thermal equilibrium of the reaction medium and effective mixing of the chemical components, contributing to the controlled and efficient reaction. Continuous stirring prevented phase separation and optimized methyl ester formation.

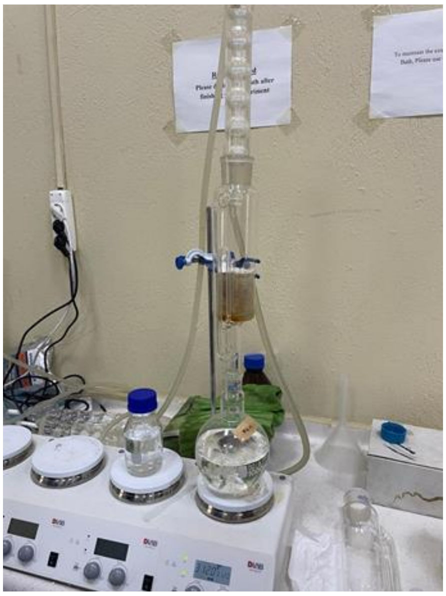

Fig. 6 Heated Magnetic Stirrer – DLAB MS-H340-S4

Mechanical Stirrer – JSR Brand

A heated magnetic stirrer was used effectively to homogenize highly viscous reaction mixtures. The device maintained the integrity and stability of the reaction solution by ensuring a continuous and even distribution of the components within the solution. This increased transesterification efficiency and positively impacted product quality.

Fig. 7 Mechanical Stirrer

Industrial Oven

Pre-drying of olive pits was carried out in a laboratory-type controlled-temperature oven. The oven operated at a temperature between 105–110°C to remove free and bound moisture from the pits. This drying process was considered a critical preparatory step in the oil extraction process because it directly impacts the efficiency of the pyrolysis process.

Fig. 8 Industrial Oven

Cooling Device – Thomson PMT TLC60

A cooling bath was used for samples requiring rapid cooling following the reaction process, particularly during the precipitation of the biodiesel phase and the separation of solvents. By providing a temperature-controlled environment, the device supported post-reaction product stabilization and increased the efficiency of phase separation.

Fig. 9 Cooling Device – Thomson PMT TLC60

III. Biodiesel production Stages

Drying of Olive Stones

The olive stones used as raw materials in this study were first stored in natural conditions to reduce free moisture content. Then, they were dried in an industrial oven at 105°C for 24 hours. This pre-drying process was performed to increase reaction efficiency in both the pyrolysis and solvent extraction oil extraction stages and to prevent the formation of undesirable byproducts.

Grinding and Cartridge Filling Process

Once the dried olive stones were processed in a suitable mechanical grinder to break them into small pieces to make them more digestible. The resulting ground stones were placed in specially designed cartridges, prepared for solvent extraction. These cartridges were designed to ensure effective solvent contact and maximize oil solubility. The cartridge design is shown in **Figure 10**.

Fig.10 Cartridge Filling

Oil Extraction with Acetone in a Reflux System

The prepared cartridges were placed in a laboratory-type reflux system for the oil extraction process. Acetone (CH_3 $COCH_3$) was added to the cartridges as a solvent, and the system was positioned on a DLAB brand magnetic stirrer heater. The reflux process was initiated, allowing the solvent to continuously evaporate and condense, bringing it into contact with the raw material. After approximately 6–7 cycles, the majority of the oils in the olive pits were converted into acetone. This process was repeated multiple times, resulting in a total volume of 1 liter of acetone-oil mixture. The applied extraction system is shown in **Figure 11.**

Fig.11 Reflux System

Separation of Acetone from Oil

The acetone-oil mixture obtained through the reflux process was transferred to a HAHN SHIN HS-2005V-N model separation device for solvent removal. Acetone's low boiling point (56°C) was utilized to remove it by evaporation. Thus, the solvent phase was completely removed, yielding approximately 1 liter of pure olive kernel oil. The purification process is presented in **Figure 5**.

Transesterification Reaction

Methanol (250 mL) at a volumetric ratio of 25% by volume and sodium hydroxide (NaOH) at a weight of 1% by weight of the oil were added to purified olive kernel oil. This mixture was stirred for 1 hour at 60°C using a JSR brand mechanical stirrer and a DLAB MS-H340-S4 model magnetic stirrer with heating. The transesterification process resulted in the formation of two distinct phases—biodiesel (upper phase) and glycerin (lower phase). This process is shown in **Figure 7**.

Precipitation Process

Following the transesterification process, the resulting mixture was left at room temperature for 72 hours (3 days) to allow phase separation to occur naturally. During this time, due to the density difference, glycerin accumulated in the lower phase and biodiesel in the upper phase. The glycerin collected in the lower phase was carefully removed, leaving only the upper biodiesel phase ready for purification.

Fig.12 Sedimentation Process (in the separatory funnel)

Washing Biodiesel with Pure Water

The biodiesel obtained after transesterification was washed with pure water to remove any remaining soap, methanol, and other residue. The washing process was carried out by adding an equal volume of pure water to the biodiesel phase, and the mixture was gently agitated to achieve homogeneity. Then, due to the density difference, the water layer that accumulated in the lower phase was carefully removed. This process was repeated multiple times to minimize impurities in the biodiesel and improve the fuel's usability.

Fig.13 Washing Biodiesel with Pure Water

In the present study, the workflow schematically shown in Figure A was followed. A six-cylinder compression ignition engine was used in the experiments. 50 mg and 100 mg TiO2 were added for every 1000 g of diesel fuel. Titanium dioxide (TiO2) with a particle size of 21 nm was used as nanoparticle. The mixtures were mixed with a mechanical stirrer at 1000 RPM for one hour. The fuels were coded as D for diesel, D_50ppm + 50 ppm TiO2 for diesel, and D_100ppm + 100 ppm TiO2 for diesel. Neodymium magnets were placed around the diesel fuel line to create a magnetic field of 1 tesla. In the experiments conducted with a magnetic field, the label "Magnetic" was added to the fuel codes to indicate the type of experiment. These three fuel types were tested in a compression ignition engine with and without a magnetic field. The experimental results are discussed in Section 3. A balance with a sensitivity of 0.5 g was used for fuel consumption measurement. Exhaust emissions were measured using a Bosch BEA 60 analyzer. Recording of engine performance data was facilitated by the PCS engine performance measurement system.

2.1.3 Nanoparticles

TiO_2 and activated carbon were used as nanoparticles in the experiments. Their properties are given in **Table 3 and 4**.

Table 3. TiO_2 specifications

Properties	TiO_2	Activated Carbon
Boiling point	1600 °C (1013 hPa)	-
Particle size	21 nanometer	-
Density	4,500 kg/cm3 (25 °C)	820-845 kg/m3
Molar mass	233.38 g/mol	-
Melting Point	1560 °C	-

Table 4. Activated Carbon (AC) specifications [16]

Properties	AC
Specific surface area (m2/g)	962.5
Porous volume (cm3/g)	0.312
Carbon (%)	52.49
Oxygen (%)	31.3
Potassium (%)	0.432
Si (%)	1.739
Ash content (%)	4.8
Iodine number (mg/g)	815.525

2.2 Preparation of fuel mixtures

Fuel samples (D100, B20D80, B20D80-Safflower, B20D80-Waste Oil, B20D80-Olive Stone, and versions with additives) were prepared in volumetric quantities and subjected to standard filtration to remove impurities before testing. They were mixed in a magnetic stirrer until homogeneous. After the nanoparticles were added to the liquid fuels, they were mixed for a sufficient time.

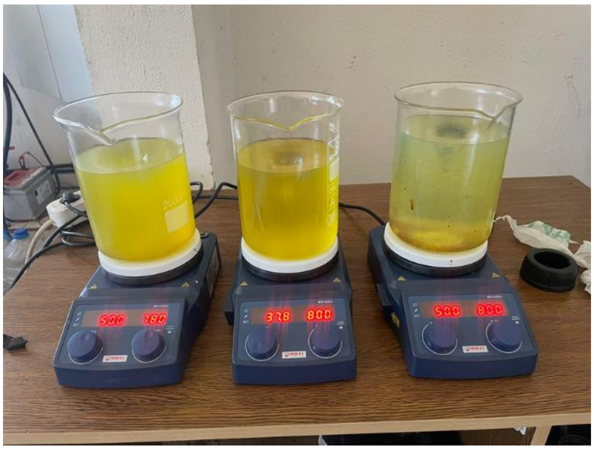

Fig.14 Preparation of fuel mixtures

After adding the nanoparticles, the mixture was mixed at 800 rpm for 30 minutes. To avoid sedimentation and ensure homogeneous use of the mixture, the fuel was used immediately after mixing.

Table 5. Fuel mixtures

Fuel Type	
D100	Pure Diesel
D100_50T	Pure Diesel + 50 ppm TiO2
D100_50T_50AC	Pure Diesel + 50 ppm TiO2+50 ppm Activated Carbon
BOS20D80	%20Oil Seeds Biodiesel+%80 Diesel
BOS20D80_50T	%20Oil Seeds Biodiesel+%80 Diesel + 50ppm TiO2
BWO20D80	%20Wate Oil Biodiesel+%80 Diesel
BWO20D80_50T_50AC	%20Wate Oil Biodiesel+%80 Diesel+ 50 ppm TiO2+50 ppm Activated Carbon

2.3 Engine Test System Setup

The engine system used in the tests was a multi-cylinder, turbocharged, electronically controlled diesel engine, connected to a dynamometer to control load and speed.

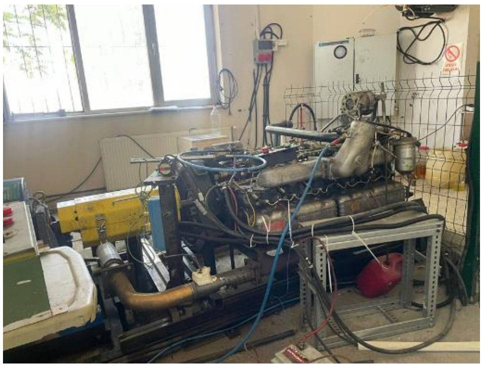

Fig.15 The Test Engine

Table 6. The Test Engine Properties

Bore and Stroke	133 mm, 140 mm
Number of cylinders	6
Displaced volume	11,670 cc
Compression ratio	16.5
Injection timing	16 'BTDC

2.3 Performance Data

Load and Speed Adjustment; For each test fuel, the engine was operated at constant speeds under low, medium, and full load. This allowed the fuel performance to be evaluated under both partial and full combustion conditions. Brake Thermal Efficiency; The mechanical power generated by the engine was calculated by dividing it by the chemical energy provided by the fuel. This calculation was based on instantaneous fuel flow, calorific value, and output power parameters. Brake Specific Fuel Consumption; The amount of fuel delivered to the engine was continuously recorded using a fuel consumption meter. Specific fuel consumption (g/kWh) was calculated by dividing the obtained values by the unit power produced.

2.4 Exhaust Gas Temperature Measurement

Fig.16 Bosch BEA Exhaust Analyzer

For each test point, instantaneous temperature values were recorded using temperature sensors at the exhaust outlet. This data was evaluated to analyze combustion efficiency and engine load levels. Exhaust Emission Analysis: Emission levels were determined using a gas analyzer attached to the exhaust outlet. Data from each test were analyzed to compare environmental performance between different fuels.

3. RESULTS AND DISCUSSION

3.1 Engine Performance

In internal combustion engines, brake thermal efficiency (BTE) is the ratio of the brake power generated to the chemical energy of the fuel. This value (BTE) is an indicator of how much of the fuel's chemical energy is used usefully [17].

$$\eta_{th} = \frac{P_b}{\dot{m}_f \times LHV} \tag{1}$$

P_b: braking power,
$\dot{m}_f$: fuel mass flow rate,
LHV: the lower heating value of the fuel [17]

In this study, the D100_50T fuel was observed to have the highest thermal efficiency (BTE). The second-highest thermal efficiency was observed for the BOS20D80_50T fuel. Consequently, the addition of TiO2 nanoparticles to both the D100 and BOS20D80 fuels was found to increase thermal efficiency. In contrast, the addition of nanoparticles to the BWO20D80 fuel did not significantly improve thermal efficiency.

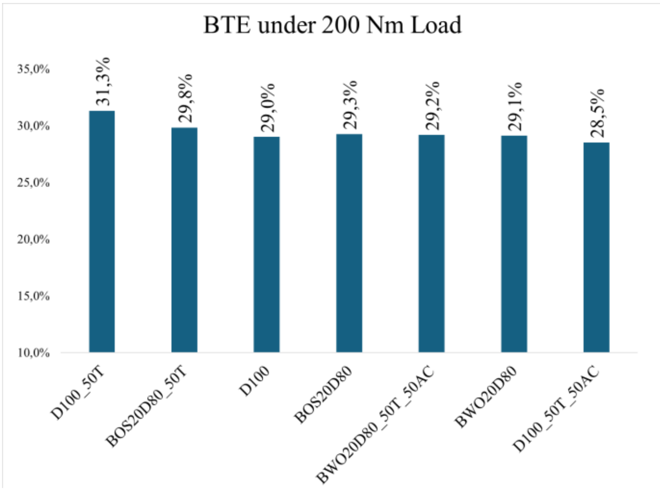

Fig.17 Brake Thermal Efficiency – under 200 Nm Load

The NO emission rates obtained in the experiments are given in Figure 18. The NO emission value of BOS20D80 fuel was dramatically higher than that of the other fuels. The addition of nanoparticles to D100 fuel caused an increase in NO emissions.

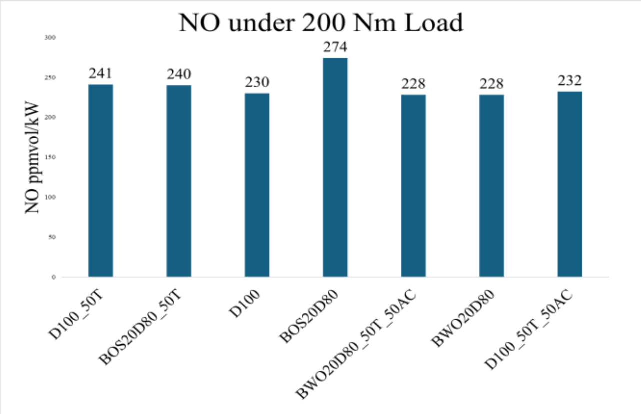

Fig.18 NO emission – under 200 Nm Load (Torque)

4.CONCLUSION& SUGGESTIONS

In this study, biodiesel was produced from olive pits. Experiments were also conducted using diesel, biodiesel (produced from olive pit oil and waste oil), TiO2, and activated carbon nanoparticles. The main results obtained from the experiments are presented below.

1- The addition of TiO2 nanoparticles to both the D100 and BOS20D80 fuels was found to increase thermal efficiency.

2- The addition of nanoparticles to D100 fuel caused an increase in NO emissions.

3- The use of agricultural wastes such as olive pits in biodiesel production should be encouraged for both economic and environmental sustainability.

4- While TiO_2 and activated carbon additives improve combustion quality in certain biodiesel types, optimization based on blend characteristics is recommended.

5- Engine tests should be expanded to include long-term performance and emissions measurements.

6- CFPP and pour point tests should be repeated in different environments to further examine fuel behavior in cold weather conditions.

7- In the future, the effects of biofuels should be investigated more thoroughly using advanced characterization methods such as particulate emissions, engine sludge formation, and combustion analysis.

REFERENCES

[1] Kumar, S. S., Rajan, K., Mohanavel, V., Ravichandran, M., Rajendran, P., Rashedi, A., ... & Afzal, A. (2021). Combustion, performance, and emission behaviors of biodiesel fueled diesel engine with the impact of alumina nanoparticle as an additive. Sustainability, 13(21), 12103.

[2] Jaikumar, S., Srinivas, V., & Meher, R. S. (2021). Combustion characteristics of direct injection diesel engine fueled with dispersant-mixed Al2O3 nanoparticle-added biodiesel blend. International Journal of Thermophysics, 42(6), 91.

[3] Rangabashiam, D., V, J., S, G., M, N., & Rameshbabu, A. (2023). Emission, performance, and combustion study on nanoparticle-biodiesel fueled diesel engine. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 45(3), 8396-8407.

[4] Sel, M. (2013). Nano katkı maddeli biyodizel yakıtlarının emisyon ve performans analizi. Yüksek Lisans Tezi,

[5] Hacıkadiroğlu, S. (2007). Dizel-biyodizel karışımlarının motor performansı ve emisyonlara etkisi. Yüksek Lisans Tezi,

[6] Kaya, A. (2006). Ham ve atık bitkisel yağlardan biyodizel üretimi ve karakterizasyonu. Yüksek Lisans Tezi,

[7] Örs, M. (2016). Bütanol katkılı biyodizelin emisyonlara ve performansa etkisi. Yüksek Lisans Tezi,

[8] Aydoğan, M. (2008). Bitkisel yağlardan biyodizel üretimi ve motor performansına etkisi. Yüksek Lisans Tezi,

[9] Nişancı, F. (2007). Bitkisel yağlardan elde edilen biyodizellerin motor performansına etkileri. Yüksek Lisans Tezi,

[10] Kaya, Y. (2010). Kanola yağından elde edilen biyodizelin motor performansına etkisi. Yüksek Lisans Tezi,

[11] Ilgazlı, A. (2010). Biyodizel yakıtlarının motor performansına ve emisyonlara etkisi üzerine deneysel bir çalışma. Yüksek Lisans Tezi

[12] Peker, K. (2009). Atık zeytinyağından biyodizel üretimi ve karakterizasyonu. Yüksek Lisans Tezi,

[13] Kül, V. S., Akansu, S. O., & Çınar, G. (2024). Experimental investigation of the effects of aqueous ammonia and water mixtures on the efficiency and emissions of a compression ignition engine. Process Safety and Environmental Protection, 191, 1495-1503. https://doi.org/10.1016/j.psep.2024.09.051

[14] Demirbas, A. (2009). Production of biodiesel from algae oils. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 31(2), 163–168. https://doi.org/10.1080/15567030701739245

[15] Kül, V. S., Akansu, S. O., Sarıtaş, M., Sinkala, H., & Ünalan, S. (2025). Investigation of the effect of utilisation of nano boron, diesel and biodiesel fuels with together hydrogen in a compression ignition engine on combustion characteristics. International Journal of Thermofluids, 101232. https://doi.org/10.1016/j.ijft.2025.101232

[16] Ossman, M. E., Fatah, M. A., & Taha, N. A. (2014). Fe (III) removal by activated carbon produced from Egyptian rice straw by chemical activation. Desalination and Water Treatment, 52(16-18), 3159-3168. https://doi.org/10.1080/19443994.2013.796895

[17] Kül, V. S., & Sarıtaş, M. (2025). Investigation of the Effect of Stearic Acid Addition to Diesel on Combustion in a Compression Ignition Engine Energy, Environment and Storage. https://doi.org/10.52924/ZDOJ8219

[18] Sarıtaş, M., & Kul, V. (2024). Effects of Magnetic Fields and Nanoparticle Additives on Diesel Engine Emissions and Performance: A Comprehensive Experimental Analysis. Energy, Environment and Storage

Journal, 4(03). https://doi.org/10.52924/ZYRI4684

[19]Kumar, N., Raheman, H. 2022. "Production, characterization and utilization of second generation biodiesel blend in diesel engine using water and nanoparticles as additives" Fuel, 308, 122063. https://doi.org/10.1016/j.fuel.2021.122063

[20] Vellaiyan, S., Subbiah, A., Chockalingam, P. 2020. "Effect of titanium dioxide nanoparticle as an additive on the exhaust characteristics of diesel-water emulsion fuel blends" Petroleum Science and Technology, 38(3), 194-202. https://doi.org/10.1080/10916466.2019.1702677