Fuel Quality of B10 and B20 Diesel From Petrol Stations

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INTRODUCTION

Petroleum diesel is an important fuel to fulfil the energy demand of the country. In 2019, a total of 8484 kilotonnes oil equivalent (ktoe) of petroleum diesel was produced from local refineries while 10583 ktoe was consumed (Energy Commission, 2022). The significant gap between the production and consumption volumes was filled by imports. Petroleum diesel is mainly used by light, medium and heavy-duty diesel vehicles for transportation of goods and people. The transportation sector posted the highest diesel consumption in the country *i.e.* 68% of the total diesel consumption in 2019 (Energy Commission, 2022). Besides on-road vehicles, diesel fuel is also used by machineries in factories, tractors in agriculture sector and boats for both fishing and transportation.

Malaysian Palm Oil Board (MPOB) initiated a research and development program on the production and use of palm methyl ester (PME) in the 1980s. After completed evaluation at laboratory scale, a pilot plant for PME production was constructed in 1985. The PME produced from the pilot plant was used for exhaustive field trials in collaboration with various parties using different diesel vehicles such as taxis, lorries and buses. These trials have concluded that PME is a suitable substitute for petroleum diesel (Choo *et al.*, 1997). PME production technology was only feasible and commercialised two decades later in 2006. Due to overwhelming response from the industry and escalating demand of biodiesel, a total of 91 production licenses have been approved by the then Ministry of Plantation Industries and Commodities in 2008 (Biofuels International, 2008). However, not all the licenses approved result in actual PME production. Last year, a total of 24 biodiesel plants were in operation with a total production capacity of 2.71 million tonnes of biodiesel per annum (Parveez *et al.*, 2023).

B5 diesel, a blend of 5% PME with 95% petroleum diesel was introduced at petrol stations to replace conventional petroleum diesel in 2011 (Yung *et al.*, 2016). The PME blending ratio increased from 5% to 7% in 2014 and subsequently to 10% in 2019 (*Table 1*). B7 diesel was introduced to the industrial sector in 2019. In 2020, the B20 programme rolled out in Langkawi, Labuan and Sarawak. To date, Euro 5 B10 diesel and B20 diesel are the mandatory diesel fuel supplied in petrol stations while Euro 5 B7 diesel is an optional fuel supplied by oil companies in selected petrol stations. This Euro 5 B7 diesel serves the purpose as alternative diesel for vehicles that claimed to be not compatible with biodiesel content >7 vol. %.

To access the performance of the biodiesel program in the country, survey was conducted by random sampling of diesel fuels sold at petrol stations. Some key fuel properties of the sample were evaluated with reference to the Malaysian Standard Specifications for diesel fuel namely MS123-3:2016 and MS 123-5:2020 (Department of Standards Malaysia, 2016 and 2020).

ANALYSIS OF COMMERCIAL DIESEL FUEL

The commercial diesel samples were obtained from petrol stations in Peninsular Malaysia. A total of 118 samples were collected from 118 petrol stations in Peninsular Malaysia in 2022. The samples obtained were analysed for the following parameters:

a) PME content (ASTM D7371)
b) ASTM colour (ASTM D1500)
c) Water content (ISO 12937)
d) Acid number (ASTM D664)
e) Kinematic viscosity at 40°C (ASTM D445)
f) Density at 15°C (ASTM D4052)
g) Flash point (ASTM D93)
h) Physical distillation at 95% recovered (T95) (ASTM D86)
i) Sulphur content (ASTM D5453)

TABLE 1. BIODIESEL IMPLEMENTATION IN MALAYSIA

Region States	Implementation date	Blending ratio (Bx)
(a) Transportation sector		
Center: Putrajaya, Melaka, Negeri Sembilan, Kuala Lumpur & Selangor	June-November 2011	5% (B5)
Southern: Johor	July 2013	5% (B5)
Eastern: Pahang, Terengganu & Kelantan	February 2014	5% (B5)
Northern: Perak, Penang, Kedah & Perlis	March 2014	5% (B5)
Peninsular Malaysia	November 2014	7% (B7)
Sabah, Sarawak and Labuan	December 2014	7% (B7)
Malaysia	February 2019	10% (B10)
Langkawi and Labuan	January 2020	20% (B20)
Sarawak (except Bintulu)	September 2020	20% (B20)
(b) Industrial sector		
Malaysia	July 2019	7% (B7)

SAMPLING LOCATION

Breakdown of the location of the diesel sampling is presented in *Table 2*. There were 50 samples taken in the Center Region which covered Selangor (20), Kuala Lumpur (10), Negeri Sembilan (9) and Melaka (11). For the Eastern Region, 10 samples were obtained from petrol stations in Terengganu and Pahang, respectively. At the Southern Region, a total of 18 samples were obtained from the center (Kluang) and Southern area (Johor Bahru). For Northern Region, samples were taken from three states *i.e.* Kedah (17), Penang (7) and Perak (6). From the 17 samples taken in Kedah, a total of 10 samples were collected from petrol stations in Langkawi Island. The samples from Langkawi Island are particularly important as this is the only location in Peninsular Malaysia where B20 program has been implemented since January 2020.

TABLE 2. LOCATION OF FUEL SAMPLING

State	Region	Number of samples
Selangor	Center	20
Kuala Lumpur		10
Negeri Sembilan		9
Melaka		11
Terengganu	Eastern	10
Pahang		10
Johor	Southern	18
Kedah - Langkawi	Northern	10
Kedah		7
Penang		7
Perak		6
Total		118

RESULTS AND DISCUSSION

Mid-infrared spectroscopy results show that most of the samples obtained are B10 diesel and the PME content is in the range of 9.20-10.45 vol. % (*Figure 1*). For the 10 samples obtained in Langkawi Island, the PME content was found to be in the range of 18.83-20.55 vol. %. Eight B7 diesel samples were obtained from each region, and the PME content is in the range of 6.36-6.99 vol. %. These B7 diesel samples serve the purpose as baseline for comparison with the B10 and B20 diesel samples.

Colour is an indication of possible contamination or product degradation. In the present study, all 118 diesel samples met the ASTM colour specification of 2.0 maximum. In fact, the colour scale readings of these samples are below 1.5 or technically recorded as L1.5 (*Figure 2*). Colour results preliminarily justified that all the samples are free of any possible contamination and degradation.

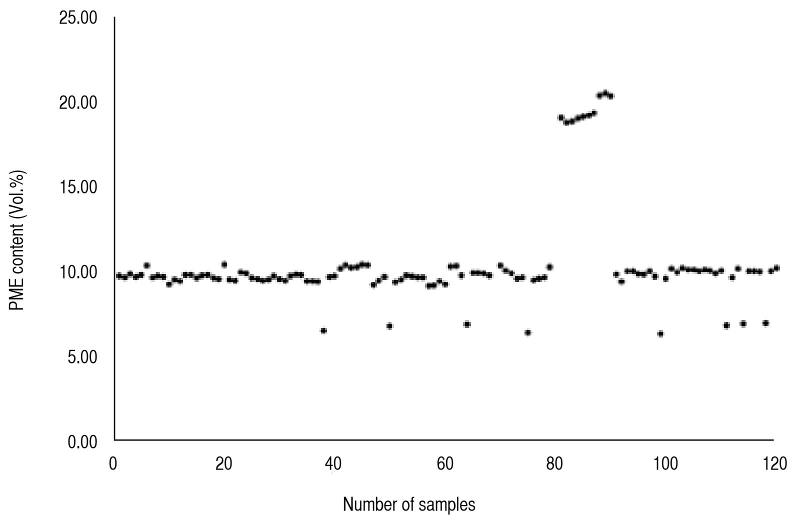

Figure 1. Palm methyl ester (PME) content in 118 commercial diesel samples obtained from petrol stations.

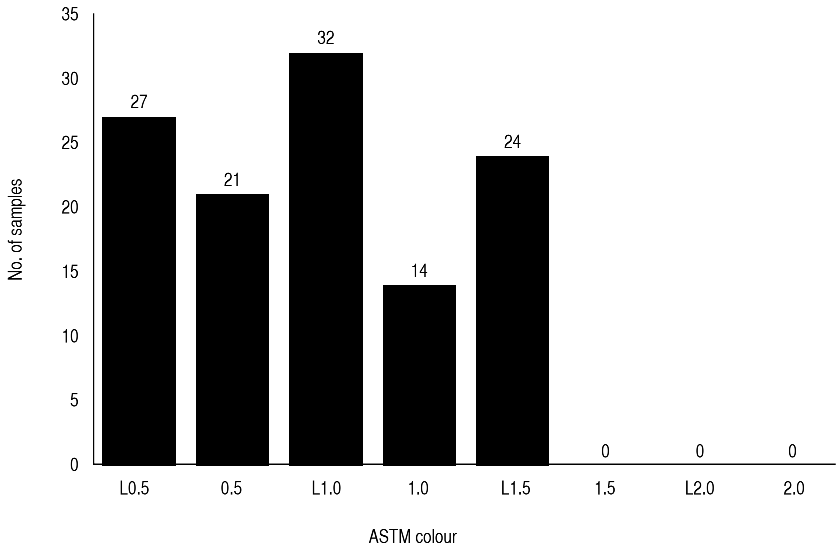

Figure 2. Colour readings of commercial diesel samples obtained from petrol stations.

Water is an undesired component in fuel. The presence of excessive water promotes microbe growth and fuel oxidation. In the present study, water content of all the samples namely B7, B10 or B20 are well below the limit of 0.05% (*Figure 3*). *Figure 4* shows that all 118 samples have acid number results well below the respective limit of 0.25 mg KOH g^{-1} and 0.30 mg KOH g^{-1} as per specifications.

For physical properties such as kinematic viscosity and density, all the samples fall within the specified ranges of 1.5-5.8 mm sec^{-1} for kinematic viscosity at 40°C and 0.810-0.856 kg L^{-1} for density at 15°C, °respectively (*Figures 5* and *6*). Blending of PME into petroleum diesel does not alter these two parameters significantly although it is commonly known that PME has higher viscosity and density readings than petroleum diesel (Yung *et al.*, 2013)

There is no significant difference for flash point of the 118 samples analysed although the flash point value of PME *i.e.* 182°C is much higher than petroleum diesel (*Figure 7*). This is because petroleum diesel is the major component of the blends. Flash point is an important parameter for storage and transportation of flammable liquid. Both petroleum diesel and PME meet the flash point limits set in their respective standard specifications.

In terms of the distillation temperature at 95% recovery (T95), again all 118 samples meet the maximum limit of 360°C (*Figure 8*). This T95 limit has been revised 10°C lower compared to the previous Euro 2M specification when the Euro 5 diesel specification was set up in 2016. Reduction of heavy components in a fuel is anticipated to contribute to lower exhaust emissions. Another parameter related to the exhaust emissions, in particular the sulphur oxide (SOx) emissions is the sulphur content of the fuel. As anticipated, the sulphur content of the diesel blends was found to be below 10 mg kg^{-1} (*Figure 9*). These values are much lower than the results obtained in previous studies *i.e.* Yung *et al.* (2016) and Yung and Loh (2018). Euro 5 diesel was initially introduced in 2014 as an optional diesel to provide a cleaner emission. The total replacement of Euro 2M diesel by Euro 5 diesel was implemented on 1st April 2021 (Lim, 2021). One of the major differences between Euro 5 diesel and previously deployed Euro 2M diesel is the significant reduction of the sulphur limit of the fuel, 98% reduction from the previous limit of 500 mg kg^{-1}. In other word, the high sulphur diesel fuel has been phased out after April 2021.

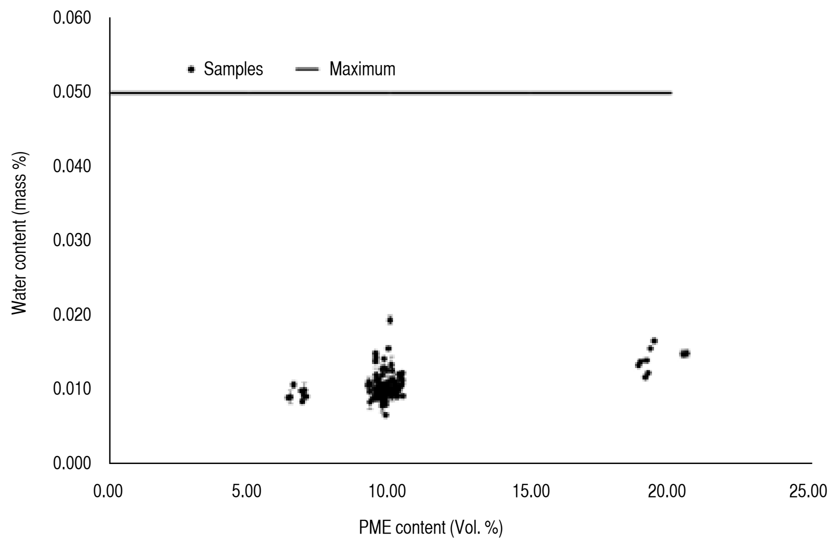

Figure 3. Water content of commercial diesel samples obtained from petrol stations.

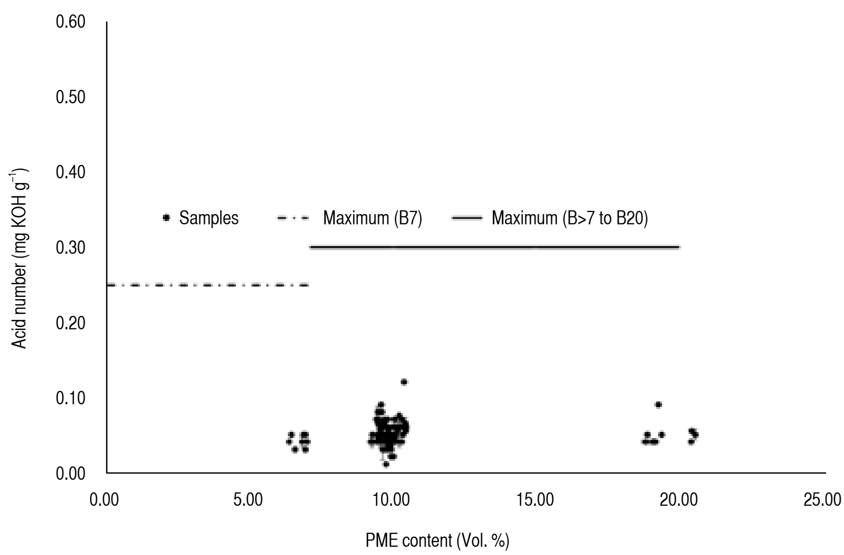

Figure 4. Acid number of commercial diesel samples obtained from petrol stations.

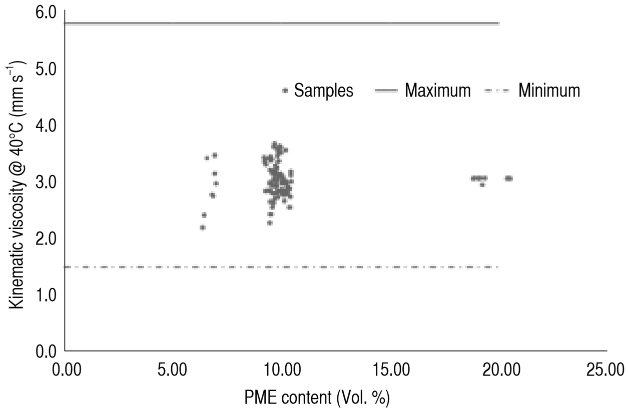

Figure 5. Kinematic viscosity at 40°C of commercial diesel samples obtained from petrol stations.

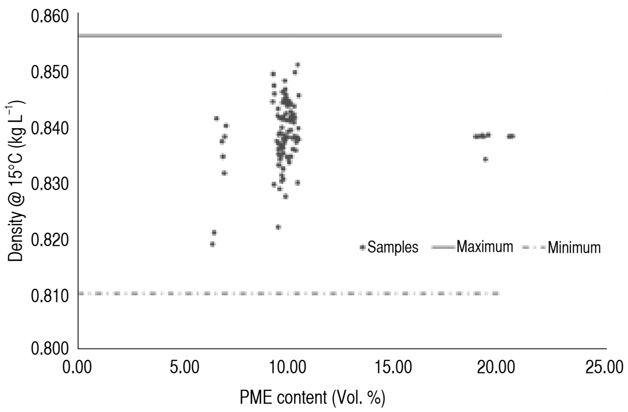

Figure 6. Density at 15°C of commercial diesel samples obtained from petrol stations.

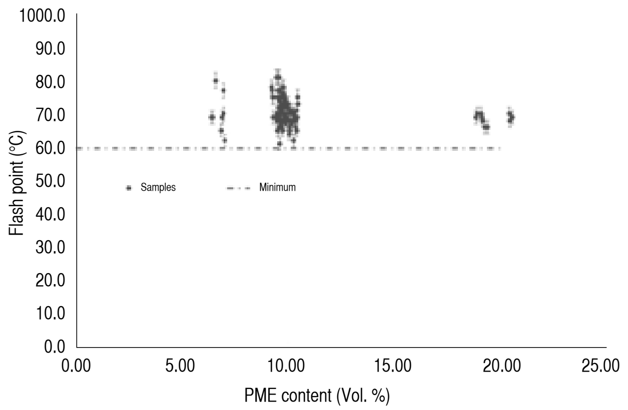

Figure 7. Flash point of commercial diesel samples obtained from petrol stations.

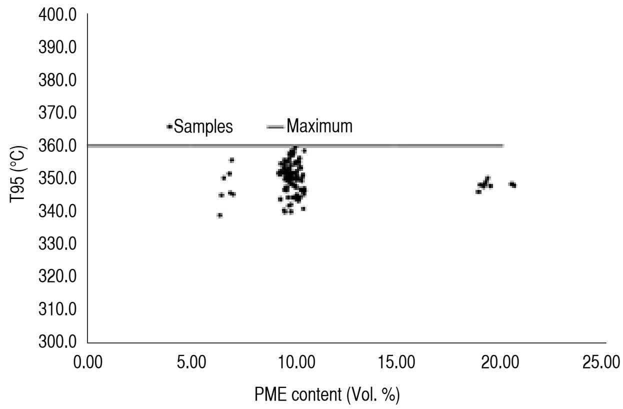

Figure 8. T95 of commercial diesel samples obtained from petrol stations.

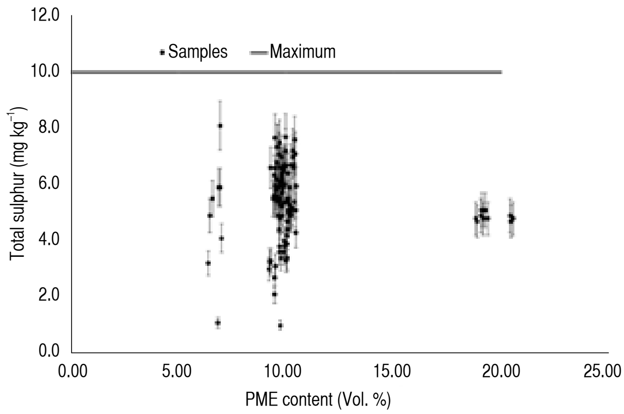

Figure 9. Total sulphur content of commercial diesel samples obtained from petrol stations.

CONCLUSION

Based on the properties evaluated, there is no significant difference among the B7, B10 and B20 diesel except the PME content. All 118 samples meet the limits set in the diesel standard specifications. As such, it is anticipated that B30 diesel is deemed safe to be used in diesel engines. Besides, the increase of PME blending ratio helps to fulfill the local demand of diesel fuel and reduces the dependency of diesel imports. The oil palm industry could voluntarily use high blend of biodiesel such as B20 or even up to B100 in its operation to offset carbon emission by own company as means to achieve business sustainability. The use of biodiesel by palm oil sectors could serve as a catalyst to encourage other industries to adopt biodiesel usage in the future.

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