Viscosity Measurement of Blended Patchouli Oil at Atmospheric Pressure and Room Temperature

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Abstract. Patchouli is an essential oil used in perfumes, cosmetics, soaps, insect repellents and also a candidate for biodiesel from non-edible oil. Patchouli oil from Aceh Province, Indonesia, is generally produced using a distillation process. The relationships between physical properties, i.e. the viscosity and quality, of patchouli oil from Aceh Province and blends with other oils, were investigated. The mixture oils used were palm oil, kerosene and lubricant oil SAE 40. The mixture compositions were 100:0; 75:25; 50:50; 25:75 and 0:100 (v/v). It was found that mixing palm crude oil (25%) or lubricant oil (25%) with patchouli oil increased the viscosity by about 41% and 72%, respectively, compared with pure patchouli oil. A 53% decrease in viscosity was observed when the patchouli oil blend contained 25% kerosene. Natural variation in patchouli alcohol (PA) and iron (Fe) content in the patchouli oil sample was found to increase the value of viscosity by up to 1.5%.

Keywords: *AAS; blended oil; GC; mixture; patchouli oil; viscosity.*

1 Introduction

Essential oils are a type of vegetable oils that have physical characteristics such as a thick liquid form, volatile content and a distinctive aroma [1]. One type of essential oil found in Indonesia is patchouli oil. Patchouli oil is produced from the steam distillation of dried leaves of the patchouli plant (*Pogostemon cablin Benth*). Patchouli oil is usually used in the perfume industry [2] and in drugs. It also has the potential to be used as biodiesel. Biodiesel is an environmentally friendly fuel consisting of alkyl esters from fatty acids that can be made from vegetable oils as well as animal fat. Vegetable oils are in the spotlight to be used as alternatives to mineral oils for the purpose of lubrication because of certain inherent technical properties such as high flash point, high viscosity index, high lubricity, low evaporative loss and biodegradability [3,4]. Environmentally

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friendly substitutes for mineral oil as lubricant are an interesting area of research in the lubricant industry within the new paradigm of sustainable technology development. In biodiesel, viscosity is one of the most important properties, showing material resistance to shear or flow [5]. Fuels that are too low in viscosity provide poor lubrication and tend to cause leaking in the engine. Conversely, viscosity that is too high causes dirty smoke because the fuel is slow to flow and harder to atomize [6].

Atabani has measured the density and viscosity of patchouli oil from Aceh province. The density was 946.6 $kg.m^{-3}$ and the kinematic viscosity was 9.82 mm^2s^{-1} at 40 °C [5]. Using these data as a reference, further measurements were made regarding patchouli oil from Aceh province. The viscosity measurement was carried out on pure patchouli oil found in several districts in the province of Aceh. This was done to see the potential of patchouli oil produced by local communities. Patchouli oil producing districts in Aceh Province include *Aceh Jaya*, *Aceh Selatan* (South Aceh), *Aceh Barat* (West Aceh), *Gayo Lues* and *Aceh Tenggara* (Southeast Aceh).

Distillation processes are used to produce the oil. It is very simple to distill the oil and the procedures used are diverse. The different methods of distillation and the geographical location of each district produce a variety of patchouli oils with different qualities. These quality differences must follow one of the standards specified in the Indonesian National Standard (SNI), i.e. 06-2385-2006. SNI has standard values for color, density, refractive index, solubility in ethanol, acid number, ester number, optical rotation, patchouli alcohol, alpha copaene and iron content.

The price of patchouli oil in the market is relatively high compared to other oils. Because of this, sellers often commit fraud by mixing patchouli oil with other types of oil thus reducing the purity of the oil. Martsiano [7] mentions oil mixtures that are often used, including palm oil and lubricant oil. With this in mind, one of the contributions of the present study was to investigate the viscosity of patchouli oil when it is mixed with other fluids. In addition, this study also considered some important characteristics of patchouli oil in relation to its viscosity, i.e. the patchouli alcohol (PA) and the iron content.

2 Methodology

Patchouli oil (PO) was taken from three districts of Aceh province, Indonesia, i.e. *Aceh Besar*, *Aceh Selatan* (South Aceh) and *Gayo Lues.* To investigate the effect of differences in purity on viscosity, blending of patchouli oil from Aceh Besar district was carried out, where the mixture composition was varied at 100:0; 75:25; 50:50; 25:75 and 0:100 (v/v). Palm oil (PLO), kerosene (KR) and lubricant oil SAE 40 (LO) were used as the mixture materials and were obtained from Banda Aceh. These were selected because they are readily available and relatively cheap.

2.1 Viscosity Measurement

The viscosities of the samples were measured using a L-version rotational viscometer (Thermo Electron (Karlsruhe) GmbH viscotester C type 399-0301-Spindel LV2, uncertainty of the measurement of 0.1 mPas).

2.2 Density Measurement

The fluid density was determined using a piknometer. This device is made of glass and its shape resembles a perfume bottle. There are several sizes of piknometers available, where the volume value is valid at the temperature printed on the instrument. Density measurement in the present work was done with a 50-ml piknometer. All measurements were done under ambient conditions (0.1 MPa and 303 K).

2.3 Atomic Absorption Spectroscopy Analysis

The iron (Fe) content in the patchouli oil from Aceh Province was measured using atomic absorption spectroscopy (AAS) by flame technique (AAS PinAAcle 900 H from Perkin Elmer). In this process, patchouli oil is prepared in quantities of 5 g and then mixed with 10 ml of nitric acid. This is done to be able to separate the oil from the Fe elements in the patchouli oil.

Mixing was done for approximately 1 h (until the oil and Fe elements have separated). During separation, the oil in the patchouli oil hardens, leaving the solution yellow. The solution was filtered and diluted using approximately 30 ml of distilled water.

2.4 Gas Chromatography analysis

The patchouli alcohol (PA) content in the samples was measured using gas chromatography (GCMS-QP 2010 Ultra from Shimadzu). Gas chromatography (GC) analysis is based on the separation of compounds. In GC there are two phases; one phase is carried out by gas while the other phase is done in a column. When passing the column, the compound will come out based on how long the compound can be held by the column. This causes a difference in retention time. Compounds with different retention times are read by a detector and matched with a database.

3 Results and Discussion

The density measurement of the patchouli from Aceh province varied from 925 to 942 kg.m^{-3} and the viscosity varied from 14 to 17 mPas, as can be seen in Table 1.

Table 1 Density and viscosity measurement of the pure samples.

Sample	Density (g/cm^3)	Viscosity (mPas)
PO from *Aceh Selatan*	0.942	16,7
PO from *Aceh Besar*	0.925	15,3
PO from *Gayo Lues*	0.934	14,3
PLO	0.895	55,3
LO SAE40	0.848	88,7
KR	0.785	1,8

Figure 1 shows the density of the patchouli oil. It was found that the density decreased by about 2% when lubricant oil was added for every 25% volume of the sample, whereas it decreased by about 1-2% when palm oil was added for every 25% volume and by about 4% when mixed with kerosene for every 25% volume, respectively. Figure 2 shows the viscosity measurement. It was found that the viscosity of the patchouli oil blended with palm crude oil at 25% volume and lubricant oil at 25 % volume increased the viscosity by about 41% and 72%, respectively, and it decreased by 53% when it was blended with kerosene at 25% volume.

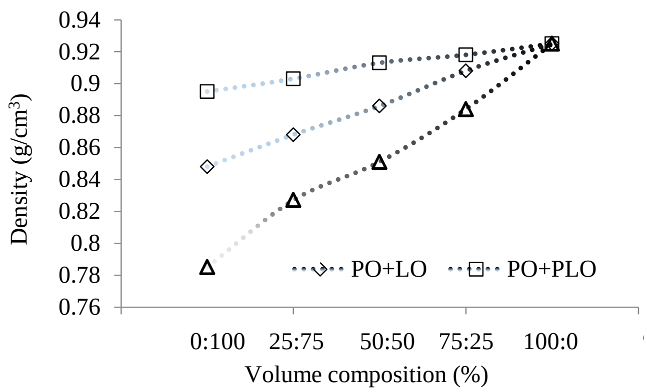

Figure 1 Density measurement with the composition of the added mixture for every 25% volume of the patchouli sample from *Aceh Besar* district.

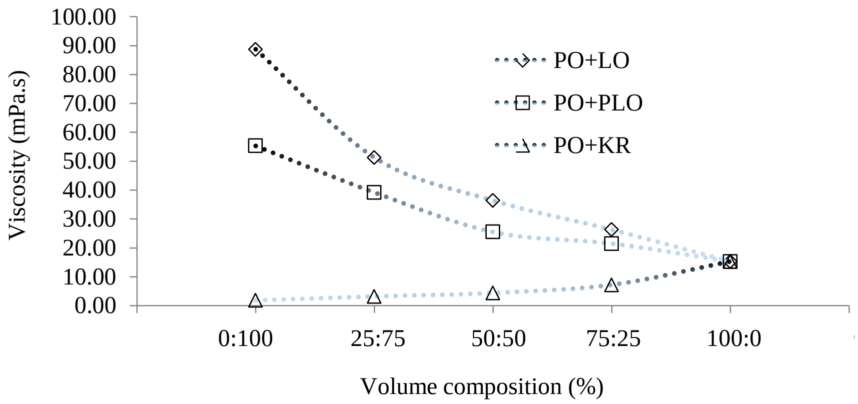

Figure 2 Viscosity measurement of blended patchouli oil at atmospheric pressure and room temperature (303 K).

Aisyah states that patchouli oil typically consists of 15 components, where the 5 biggest percentages are patchouli alcohol (32.60%), d-guaiena (23.07%), a-guaiena (15.91%), seychellena (6.95%) and a-patchoulena (5.47%) [8]. These five major components have also been identified by Corine and Sellier [9]. Patchoulol ($C_{15}H_{26}O$) is a maker compound responsible for the patchouli oil scent, representing around 40-50%. A simulation of the patchouli oil extraction process using patchoulol as the modeled molecule in different solvents, namely acetone, ethanol, and hexane, has been carried out by Adam, *et al.* [10]. The aim of the simulation was to recognize the molecular interaction between patchoulol molecules and solvent molecules through hydrogen bonding and the repulsion forces between them due to the abundance of hydrogen atoms in the patchoulol molecule [10]. Table 2 gives the chromatogram results of patchouli oil from the present research and from Kusuma and Mahfud [11].

The 5 major components were also identified. Based on the GC result it was found that patchouli oil sample from Aceh Selatan had 21 peaks, followed by Aceh Besar with 18 peaks and Gayo Lues with only 15 peaks (Figure 3). Patchouli alcohol began to appear at 16-17 minutes with a peak at minutes 17.340-17.466 in the present data. Kusuma and Mahfud extracted patchouli oil from East Java province, Indonesia, using a microwave hydro distillation method as a new green technique (with and without air) [11]. As can be seen in Table 3, the patchouli alcohol from Aceh province had a relatively high value compared to that found by the other researchers. In particular, the patchouli oil from *Aceh Besar* district had the highest patchouli alcohol content (42.61%).

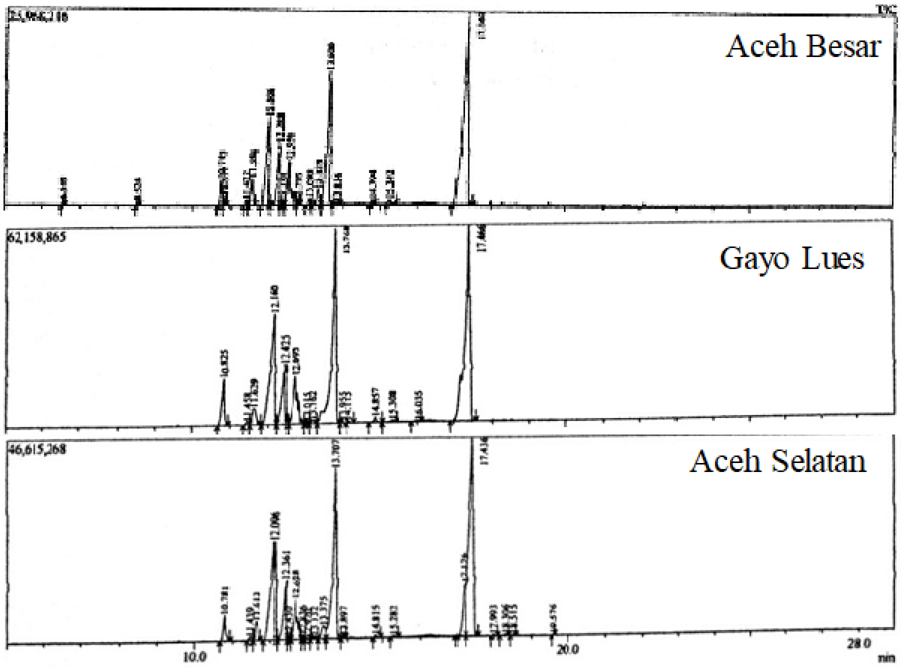

Figure 3 Result of GC measurements to estimate patchouli alcohol content in the sample.

An analysis report by AAS shows that patchouli oil from *Aceh Besar* has the highest iron (Fe) content, as is also apparent in Table 3. This is strongly related to the distillation process, as shown in Reference [12]. Alfian found that the iron content becomes low when distilled with a glass tube; it is almost the same as the iron content in the patchouli leaf itself. When the distilling process used a stainless steel tube, the value increased and when the tube was made of steel only, the value was 6.02 ppm [12]. These results are consistent with the present research. In addition, the metal content of iron (Fe) contained in patchouli oil can also be seen from its color, where the more metal (iron) content, the darker the color (Figure 4).

Figure 5 shows the apparent color of blend with 50:50 (v/v) compositions of patchouli oil (*Aceh Besar*) with kerosene, palm oil and lubricant oil. From the figure, we can see that patchouli oil blend with lubricant oil had a darker color. The blend with kerosene and palm oil had almost the same color. Thus, we should take care when drawing conclusions after analyzing samples that are suspected of being diluted with other oils. On the other hand, the patchouli alcohol (PA) and Fe content in the sample of patchouli oil can influence the value of viscosity from 14 to 16 mPas, as can be seen in the Table 3.

Arumugam, *et al.* [15] report in their work that vegetable oil as a rapeseed oil bio-lubricant has ash content 70% lower than regular SAE20W40 used in a biodiesel fueled engine. The ash content included Fe, Al, Pb and Cu wear. This research suggested that Fe content should be as low as possible to be applicable as biodiesel [15]. Note also that the viscosity of biodiesel should be in the range applicable for biodiesel; it was found that more particles in the fluid will increase the viscosity value. In the present work, the PA and Fe content are interesting because patchouli oil is often used in the perfume and drug industry.

Table 2 Major composition identified by gc for patchouli oils from Indonesia.

Name	*Aceh Besar*	*Aceh Selatan*	*Gayo Lues*	***Trenggalek*, East Java, Indonesia**	
		Area (%)		**MHD***	**MAHD***
α-Gurjunene	2.33	-	-	12.18	11.57
Trans-Caryophyllene	5.06	4.38	2.32	-	-
b-Caryophyllene	-	-	-	4.63	5.42
Aromadendrene	12.89	14.57	-	-	-
Seychellene	6.99	5.96	6.49	8.42	8.41
α-Patchoulene	6.56	6.40	-	11.13	11.54
b-Patchoulene				2.87	6.56
DehydroAromadendrene	19.20	-	-	-	-
Patchouli Alcohol	42.61	34.85	33.04	26.32	25.23
Calarene	-	2.61	11.91	-	-
d-Guaiene	-	22.62	27.03	14.69	11.89
Naphthalene	-	6.29	-	-	-
a-Guaiene	-	-	17.16	-	-
Valencene	-	-	-	3.77	-
Viridiflorol	-	-	-	5.93	5.59
1-(Propen-2-yl)-4-methylspiro[4.5]decan-7-one (isomer B)	-	-	-	2.64	2.34

* Microwave hydrodistillation (MHD) and microwave air-hydrodistillation (MAHD) [11]

Figure 4 Effect of iron content on the apparent color of the patchouli oil from (a) *Aceh Besar*, (b) *Gayo Lues* and (c) *Aceh Selatan.*

Figure 5 Apparent color of mixture with 50:50 compositions of patchouli oil (*Aceh Besar*) with (a) kerosene (b) palm oil and (c) lubricant oil SAE 40.

Table 3 Summary of patchouli alcohol and Fe content measurements in patchouli oil samples from various researchers.

Reference	Patchouli Alcohol (%)	Fe (ppm)	Viscosity (mPas)
Aceh Selatan	34.85	3.467	16.7
Aceh Besar	42.61	63.84	15.3
Gayo Lues	33.04	6.103	14.3
Ref. [12]			
Sample A	-	0.5611	-
Sample B	-	0.431	-
Sample C	-	0.799	-
Sample D	-	6.020	-
Ref. [13]	31.09	-	-
Ref. [14]	22.98	-	-

Note: sample A: = patchouli leaf, sample B = distilled with glass tube, sample C = distilled with stainless steel tube, and D = distilled with steel tube

4 Conclusion

Measurements conducted on patchouli oil from Aceh province using a rotational viscometer showed that the viscosity of *Aceh Selatan* patchouli oil is relatively high compared to samples from *Aceh Besar* and *Gayo Lues*. As for blended patchouli oil, it was found that patchouli oil blended with kerosene gave a low viscosity value compared to patchouli oil blended with palm oil or lubricant oil. Based on the measurements by GC and AAS, it is concluded that the patchouli alcohol content and the iron content in patchouli oil have an effect on the viscosity of patchouli oil, i.e. the viscosity tends to increase with increasing iron content and patchouli alcohol content in the sample.

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