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PRELIMINARY STUDY ON THE ESSENTIAL OIL OF *CANARIUM LUZONICUM* (BLUME) A. GRAY AS A POSSIBLE SUPPLEMENT TO DIESEL OIL*

Luz Oliveroz-Belardo, Zenaida B. Galpa and Ma. Judith P. Abadiano
Philippine Women's University, Manila, Philippines

ABSTRACT

The oleoresin of *Canarium luzonicum* (Blume) A. Gray gave an average yield of 30% essential oil upon water distillation. Fuel tests on the oil gave encouraging indications for its possible use as a liquid fuel. The heating value of the oil is not too far behind those of the heating values of foreign crude oils. Engine performance tests showed that the oil, in a blend with diesel oil in a 1:3 (oil to diesel) proportion, could run a ISUZU 240 diesel motor vehicle. In this dilution, one liter of the blend covered a distance of six kilometers at the speed of 80 kilometers per hour in the road test.

Introduction

The present paper is part of a continuing study on petroleum-like products from oleoresins of Philippine plants. A rich source of oleoresin is *Canarium luzonicum* (Blume) A. Gray, family Burseraceae. It is a large tree (Fig. 1) reaching a height of about 35 meters and a diameter of 1 meter or more. The tree flourishes at low and medium altitudes in the primary forests in the Philippines. It is known locally by the name *pili* and is the principal source of the oleoresin, Manila elemi of commerce.

The oleoresin oozes from the trunk of *C. luzonicum* when the bark is tapped, Fig. 2. Locally, it is used as an illuminant in the form of a torch. In preparing the torch, the resin is rolled into shape, dirt and chips included to make it stiff, and is then wrapped in a leaf of the *anahaw, Livistona rotundifolia* (Lam.) Mart. (Quisumbing, 1978). When this is lighted, it gives a very brilliant large flame that continues to burn, lighting the environment for a long time.

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Figure 1. Picture showing the tree of *Canarium luzonicum* (Blume) A. Gray with some coconut trees in the foreground and background (Actual Height: Approximately 30 meters).

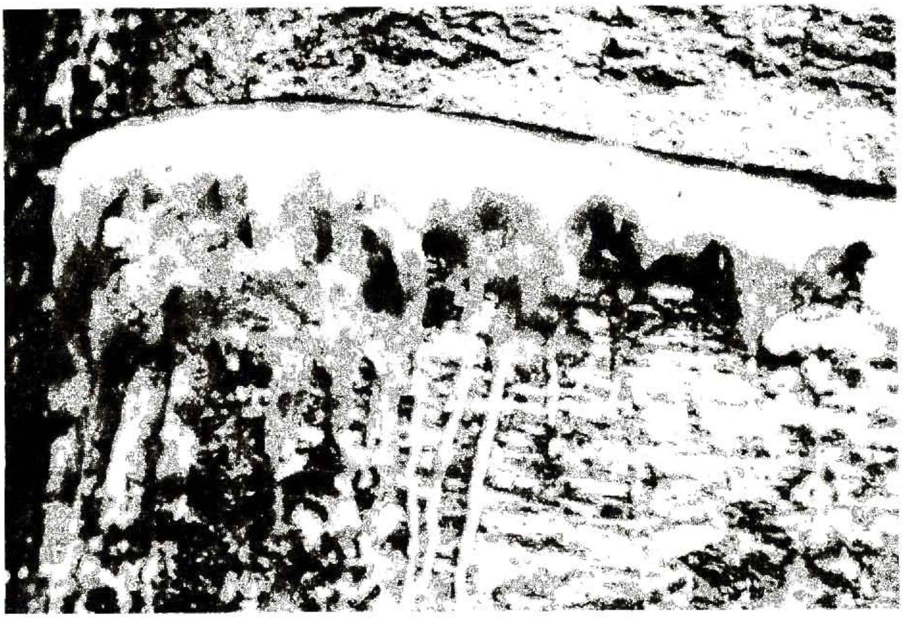

Figure 2. Picture showing the oleoresin oozing from the tapped trunk of *Canarium luzonicum* (Blume) A. Gray.

The illuminating effect is highly indicative of the possible use of the oleoresin or parts thereof as a fuel. This concept led to the main objective of this study – to separate the oil from the oleoresin of *Canarium luzonicum* (Blume) A. Gray and study its properties to determine whether or not it would be suitable as a liquid fuel.

Materials and Methods

Raw material

The material used in this work is the fresh oleoresin that was tapped from the trunk of *Canarium luzonicum* (Blume) A. Gray from which the essential oil was obtained. The main source of the oleoresin was Quezon province, Philippines.

Hydrodistillation of the oil

Fresh oleoresin of *C. luzonicum* was charged into a metallic still that was so designed for a hydrodistillation procedure. The oily distillate was separated from the aqueous distillate and was treated with anhydrous sodium sulfate to remove traces of water. The oil was measured, then placed in dark colored bottles, and stored in a cool dark place.

Physical and chemical constants of the oil

Some physical and chemical constants that are routinely studied for essential oils were determined. They are: refractive index, specific gravity, congealing point, acid value, saponification value and iodine number after Jenkins, *et al.* (1949).

Fuel tests

For the purpose of getting an insight into the potentiality of the oil for use as source of energy, fuel tests that are usually performed for petroleum oil and petroleum oil products were tried on the essential oil of the oleoresin of *Canarium luzonicum* (Blume) A. Gray.

Flammability

One and a half ml of the oil was placed in an evaporating dish and ignited with a match stick. The resulting flame as well as the duration of burning was observed.

Illuminating property

Five ml of the oil was placed in the tank of a storm lamp. The tip of the wick of the lamp was ignited and the glass chimney was put in place. The wick was adjusted until no smoke issued from the flame. The illuminating effect and duration of illumination were noted.

Volatility

One ml of the oil was weighed in a tared shallow dish, and exposed to normal atmospheric condition. The weight of the oil was taken every two hours initially, and, subsequently at random until constant weight. For comparison, a similar test was conducted on samples of diesel oil, gasoline, and kerosene.

Heating value

The energy content of the essential oil of *C. luzonicum* was measured in a Parr adiabatic automatic bomb calorimeter. The average of the results obtained was compared with the heating values recorded in literature for a number of crude oils in other lands.

ASTM distillation test

The method is prescribed by the American Standard for Testing and Materials (Jones, 1966), ASTM for short, in which 100 ml of *C. luzonicum* oil was placed in a 250 ml capacity Florence flask, heated and the initial boiling point noted. The temperature at which certain percentage of the oil passed off was recorded. Finally, the temperature at which the last drop evaporated was noted. The distillation values were plotted and the resulting curve was compared with similar fuels of known standard requirements or specifications.

Tests for other characteristics

Determination of viscosity, gravity, water and sediment, sulfur, cetane index, cloud point, pour point and flash point were duplicated and corroborated through the courtesy of the Quality Control Laboratory of Petrophil Corporation, Manila, following the procedure for *Typical Inspection* for Petron Rev 2000, and *Specifications for Diesel Fuel* for Conradson Carbon Residue.* The gum content of the oil was determined by the method prescribed by the American Standard for Testing and Materials.**

Fractionation of the essential oil of C. luzonicum

Analogous to the refining of crude petroleum oil, essential oil can be separated into its components by way of fractional distillation which must be done under reduced pressure.

100 ml of the essential oil of *C. luzonicum* was fractionally distilled at a reduced pressure ranging from 65 to 75 mm pressure. Energy contents of the fractions were determined.

*Annual Book of ASTM Standards, 1981, Part 23 – Petroleum Products and Lubricants (1): D56-D1660. American Society for Testing and Materials, Easton, Md., USA. pp. 123-129.

**Annual Book of ASTM Standards, 1979. Part 23 – Petroleum Products and Lubricants (1): D56-D1660. American Society for Testing and Materials, Easton, Md., USA. pp. 191-193.

Miscibility tests

For an oil to be successfully used as a fuel additive, it has to be miscible with existing conventional fuels in the market. For this purpose, miscibility tests were conducted. To 1 ml each of *C. luzonicum* oil, increasing amounts of diesel oil, gasoline, and kerosene were separately added. The mixture was shaken continuously for 5 minutes, and then allowed to settle. If no interfacial meniscus was observed, the pair was considered miscible, but if a meniscus was present, the pair was regarded immiscible (Hodgman, 1953).

Engine performance test

The only motor vehicle that was available at the time for road test was a ISUZU 240. The oil of *C. luzonicum* was fed into the motor vehicle, first as pure oil itself and subsequently as blends with diesel oil in increasing amounts of the latter. Road test was performed. The consumption of the fuel in relation to distance covered at a speed of from 60 to 80 kilometers per hour was noted. The engine parts were ocularly inspected for possible damage and other untoward effects.

Results and Discussion

Freshly collected oleoresin from the trunk of *Canarium luzonicum* (Blume) A. Gray gave, upon hydrodistillation, an average of 30% essential oil. The oil was pale yellow in color with a somewhat spicy taste. It had a lemon-like odor which may be explained by the presence of limonene. Predominantly observable were the contributory odors of familiar terpenes like myrcene, p-cymene, and oxygenated terpene derivatives such as cineole, elemol, and elemicin, some of which were cited by Guenther (1950). A most detailed study on the chemical composition of Manila elemi oil was reported by Lawrence (1981) who identified about 16 components as listed in Table 1. In that study, limonene was found out to be the major component of the oil, followed by α-phellandrene, and elemol. The combination of all the pleasant odors of all those terpenes and their oxygenated derivatives must have contributed to the pleasant odor of the oil of Manila elemi.

Some physical and chemical constants of the oil studied in the present work were determined. The results are shown in Table 2. It will be noted that the highest chemical constant was the iodine value which is reflective of a high degree of unsaturation in contrast to petroleum and petroleum products which contain mainly saturated hydrocarbons. Unsaturation may not pose a problem for as long as it is predominantly endocyclic.

As to the flammability test, the oil burned immediately with a smoky but bright large flame and continued to burn for 36.6 seconds, Fig. 3.

With the use of 5 ml of oil, illuminating test resulted in illuminating a dark room for 3 hours and 10 minutes, Fig. 4.

The oil was found to be volatile to the extent of 69.17%, much higher than the percentage volatility of diesel oil of 19.81% but lower than those of kerosene and gasoline which are in the 99.9% range. This could brand the oil as very volatile.

Table 1. Chemical composition of the essential oil of the oleoresin of the trunk of *Canarium luzonicum* (Blume) A. Gray *

Compound	*Percentage*
α-pinene	0.4%
myrcene	2.4
α-phellandrene	15.1
limonene	54.1
1,8-cineole	2.5
β-phellandrene	0.8
γ-terpinene	0.4
ρ-cymene	1.5
terpinolene	0.6
carvotanacetone	0.1
α-humulene	0.1
carvone	0.2
trans-p-menth-1(7),5-dien-2-ol	0.3
methyl eugenol	0.3
elemol	15.0
elimicin	3.5

*According to B.M. Lawrence, Director of Research and Development, RJR Technical Co., Avoca Division, Winston-Salem, NC, USA.

Table 2. Physical and chemical properties of the essential oil of *Canarium luzonicum* (Blume) A. Gray

Refractive index	$n_D^{30°}$	1.4674
Specific gravity	d_{30}^{30}	0.8580
Congealing point		-3°C
Acid value		0.8231
Saponification value		6.2866
Iodine value		136.83

The energy content of the oil under consideration was found to be 19,015 Btu/lb or 10,564 Cal/g as measured with a Parr adiabatic automatic bomb calorimeter. When this is compared with heating values that are recorded in literature for some petroleum crude oils abroad (Hodgman, 1953), it will be noticed that while the heating value of the essential oil of *C. luzonicum* is lower than those of Kansas, Texas, Oklahoma, Pennsylvania, and Wyoming crude oils, it is higher than those of Mexico and California crude oils, as shown in Table 3.

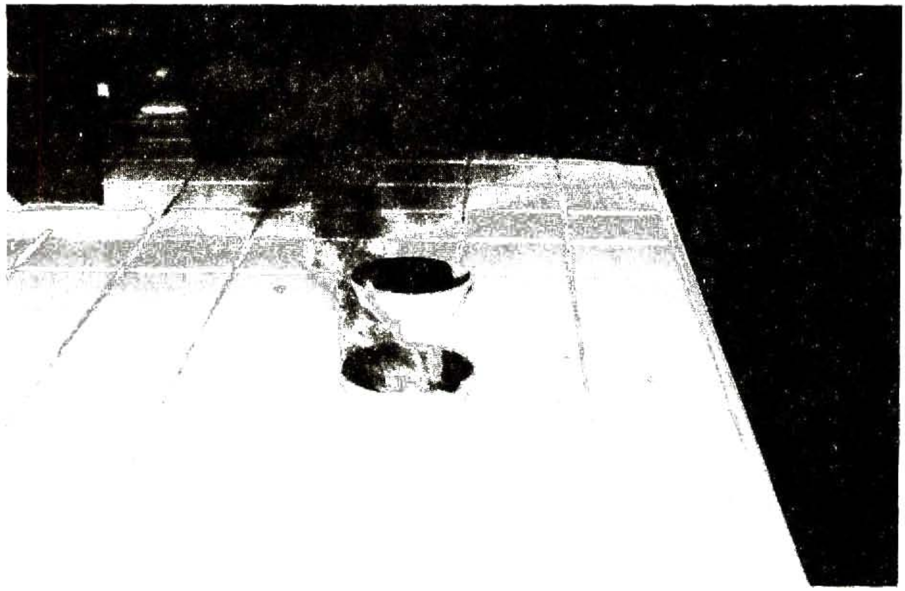

Figure 3. Picture showing the luminous flame produced by igniting the essential oil of *Canarium luzonicum* (Blume) A. Gray.

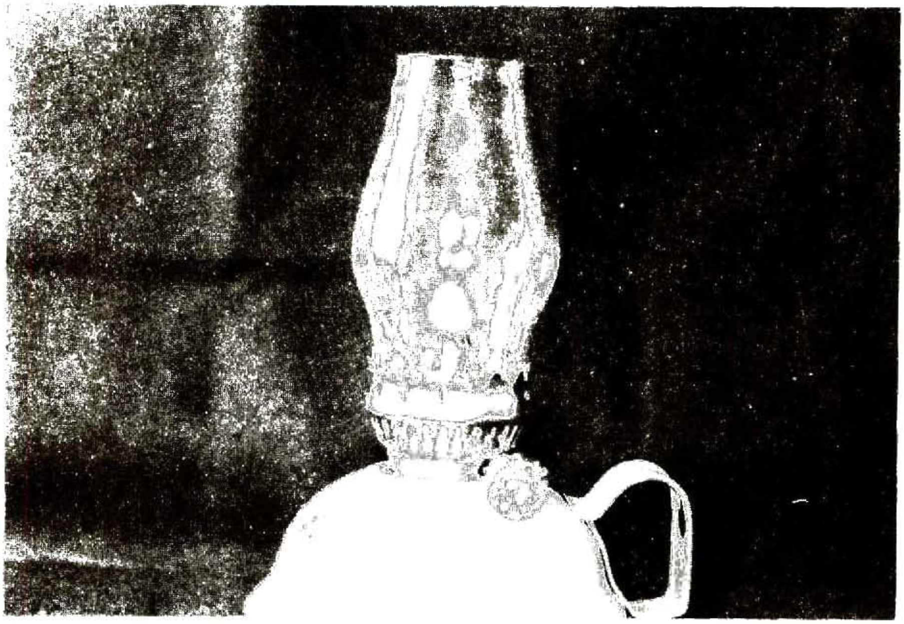

Figure 4. Picture showing a lighted storm lamp utilizing the essential oil of *Canarium luzonicum* (Blume) A. Gray.

Table 3. Comparative energy contents of some oils and *Canarium luzonicum* (Blume) A. Gray oil

Oils	*Cal/g*	*Btu/lb*
Mexico crude oil	10,419	18,755
California crude oil	10,506	18,910
C. luzonicum oil	10,564	19,015
Kansas crude oil	10,628	19,130
Texas crude oil	10,811	19,460
Oklahoma crude oil	10.834	19,502
Pennsylvania crude oil	10,836	19,505
Wyoming crude oil	10,839	19,510

A reliable and widely used method of determining the value of liquid fuels is known as the ASTM Distillation Test. The temperature at which the 10, 50, and 90% point of the fuel are distilled reveal a very significant information. It relates the volatility characteristics of the fuel to engine performance. The 10% point is related to engine starting, 50% point to the engine warm-up properties of the fuel, and the 90% point provides a good indication of fuel performance. From the distillation pattern of the oil of *C. luzonicum* a distillation curve was plotted, Fig. 5. It can be seen from the curve that the characteristic of *C. luzonicum* oil is in the

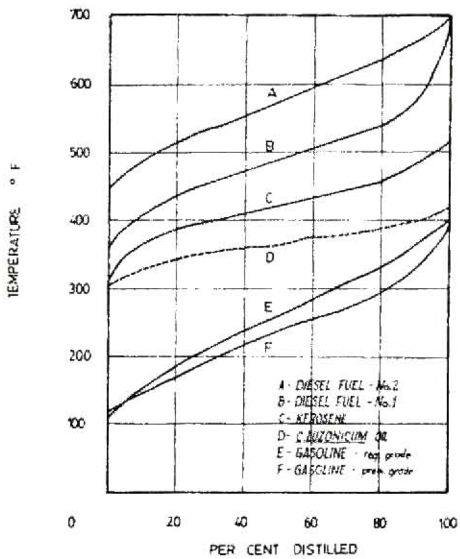

Figure 5. Distillation-test curb of *Canarium luzonicum* (Blume) A. Gray with reference to other fuels*.

*Based on the data from F.R. Jones. 1960. "Farm Gas Engines and Tractors", 4th ed. Mc Graw-Hill Book Co., Inc., New York, p. 158.

midrange of diesel and gasoline. This shows that the oil of *C. luzonicum* per se (original oil) can not be used as complete substitute for diesel or for gasoline. Its high volatility and its low cetane index are properties that disqualify it as substitute for diesel. However, it is probable that some of its fractions can substitute for gasoline provided that certain modifications be adopted in the process of fractionation. Also, in similar manner that petroleum oil refiners mix very volatile gasoline with heavier and lower grade gasoline (Jones, 1966), mixtures or blends could probably be made for *C. luzonicum* oil with known liquid fuels.

The results from the Typical Inspection tests were compared with the record for Petron Rev 2000 diesel oil, Table 4. As can be seen, the heating value of *C. luzonicum* oil is not too far below that of Petron Rev 2000 diesel oil.

The viscosity of the essential oil was found to be lower than 32 SSU (Saybolts seconds universal) which is below the limits set by the Philippine National Standards of the Philippine Standard Agency, Ministry of Trade and Industry Liquid fuels with low viscosity tend to be injected at an earlier time in the cycle for compression-ignition engine.

The gravity API at 15.6°C of 34.016 falls within the category of diesel fuel.

As to water, sediment, and sulfur, the oil of *C. luzonicum* registered the presence of only negligible quantities. Water and sediment may affect the flow of oil in engine using injection systems and adversely affect proper engine performance. Sulfur leads to serious corrosion if condensation occurs due to the formation of sulphuric acid.

Table 4. Typical inspection for Petron Rev 2000 diesel oil and *Canarium luzonicum* oil

Typical Inspection	*Petron Rev 2000 Diesel Oil**	*C. luzonicum*
Heating value, Btu/lb	19,650	19,015
Viscosity, SSU at 37.8°C	38	below 32
Gravity, °API at 15.6°C	36	34.016
Water and sediment, % vol	trace	negligible
Sulfur, % mass	0.8	negligible
Calculated Cetane index	55+	15
Cloud Point, °C	+4	-20
Pour Point, °C	-4	below -70
Flash Point, °C	66	43.3
Color, ASTM	2	–
Distillation: 90% recovery, °C	357	–

*Values corresponding to Petron Rev 2000 Diesel Oil were adapted from *Petron Basic Line*, 6th Ed., Marketing Technical Services, Petrophil Corporation, Manila, Philippines, 1984. pp. 4-5.

The cetane index or cetane number of 15 for the oil of *C. luzonicum* is low basing it from the limits specified by the Philippine National Standards set at a minimum of 35. As cetane index signifies the starting or ignition quality of a liquid fuel, the low cetane index means a low starting quality of the oil of *C. luzonicum.* This was manifested during its use in the engine performance test wherein the engine of the vehicle (ISUZU 240) started only for a while and stopped immediately.

The cloud point of -20°C for *C. luzonicum* oil indicated that it was free from waxy or other materials that might separate on cooling. Cost-wise this is an advantage because liquid fuels that become highly turbid on cooling may not command a good price.

The pour point of a liquid fuel is taken into consideration in relation to its use in gravity lubricating system. Below a temperature specified for pour point, it might be hazardous to use the fuel for the purpose. In this respect, the pour point of -70°C for *C. luzonicum* oil seems to be a favorable indication.

Comparing the flash point of Petron diesel oil with that of *C. luzonicum* oil, the latter "flashes" at a lower temperature, 43.3°C than Petron, 66°C, signifying that *C. luzonicum* oil has more lower boiling combustible components than Petron diesel oil. This observation could mean that *C. luzonicum* oil is less likely to cause difficulty in its combustion, but would probably require greater precautions for safety in its use.

The data obtained under the Typical Inspection for the essential oil of *C. luzonicum,* were also compared with Specifications from Philippine National Standards. The comparison is shown in Table 5. It can be seen that *C. luzonicum* oil has values closer to the specifications of Philippine National Standards.

Table 5. Comparison of the properties of *C. luzonicum* oil with specifications for diesel fuel

Characteristics	*Limits**	*Oil of C. Luzonicum*
Ash, % weight	0.02 max.	–
Conradson Carbon Residue, % wt.	1.0 max.	trace
Calculated Cetane Index	35 min.	15
Pour Point, °C	21.1 max.	below-70
Flash Point, °C	54.4 min.	43.3
Viscosity, SSU at 37.8°C	32-60	below 32
Water and sediment, % vol.	0.20 max.	negligible
Sulfur, % weight	1.0 max.	negligible

*From Philippine National Standards. "Specification for Motor Gasoline". Philippine Standard Agency, Ministry of Trade and Industry.

The Conradson carbon residue determination recorded only "trace" for *C. luzonicum*, lower than the maximum of 1 under specification from Philippine National Standards. This result is a plus factor for *C. luzonicum* oil. Table 5 shows data obtained for *C. luzonicum* oil as compared with specifications for diesel fuels.

The gum test for *C. luzonicum* oil gave 749 mg/100 ml of the oil, very high compared to gasoline requirement of 4 mg/100 ml. This result disqualifies *C. luzonicum* oil as a substitute for gasoline.

Fractional distillation of 100 ml of the essential oil of *C. luzonicum* under reduced pressure ranging from 65 to 75 mm gave six fractions. The energy content of each fraction was measured. The results are shown in Table 6. It was observed that the first three fractions possessed higher heating values than the original oil. Considering the percentage yield in which the fractions would be available and the amount of energy their burning would generate, the best fractions to investigate are fractions 2 and 3, both of which were present in fairly large amounts. Although fraction 1 showed a much higher heating value compared with those of the others, there was, however, too little of it to allow further investigation at the time.

Table 6. Fractionation of 100 ml of the essential oil of *Canarium Luzonicum* (Blue) A. Gray

Fraction	*Volume (ml)*	*Dist. Range (°C)*	*Percent %*	*Pressure (mm Hg)*	*Heating Cal/g*	*Values Btu/lb*
1	5.4	80-90	5.4	70-75	10,821	19,477.80
2	15.0	102-114	15.0	75	10,842	19,514.99
3	21.2	115-118	21.2	65	10,728	19,310.44
4	11.9	152-164	11.9	70-73	10,093	18,166.88
5	7.1	184-204	7.1	70	9,468	17,041.91
6	4.6	208-210	4.6	67	9,421	16,958.27
Residue	10.8	over 210	10.8		9,519	17,134.88
Total	76.0					
			Whole Oil		10,564	19,015

Because indications seem to negate the use of *C. luzonicum* oil per se as complete substitute for diesel or gasoline, it was deemed necessary to perform miscibility tests prior to doing the engine performance test. Fixed amount of *C. luzonicum* oil was mixed with separate amounts of diesel oil, gasoline, and kerosene in varying quantities with 0.25 increments from 1:0.005 until 1:5 proportion was reached. The results are shown in Table 7. *C. luzonicum* oil was observed to have good blending chracteristics with the liquid fuels used.

The properties of the essential oil of *C. luzonicum* were compared with the characteristics of some common liquid fuels recorded in literature. The comparisons are shown in Tables 8 and 9.

Engine performance test for C. luzonicum oil

The engine performance test was a phase in our work that was preceded by no little amount of anticipation because it was going to be the crucial test, the concluding step that would prove or disprove the speculations generated by the

Table 7. Miscibility tests: Essential oil of *Canarium luzonicum* (Blume) A. Gray with diesel, gasoline, and kerosene

Ratio of C. luzonicum oil to known fuels	*Diesel Oil*	*Gasoline*	*Kerosene*
1:0.005	immiscible	immiscible	immiscible
1:0.0075	slightly miscible	slightly miscible	slightly miscible
1:0.025	miscible	miscible	miscible
1:0.05	miscible	miscible	miscible
1:0.075	miscible	miscible	miscible
1:0.25	very miscible	very miscible	very miscible
1:0.5	very miscible	very miscible	very miscible
1:0.75	very miscible	very miscible	very miscible
1:1	very miscible	very miscible	very miscible
1:1.25	very miscible	very miscible	very miscible
1:1.5	very miscible	very miscible	very miscible
1:1.75	very miscible	very miscible	very miscible
1:2	very miscible	very miscible	very miscible
1:2.25	very miscible	very miscible	very miscible
1:2.5	very miscible	very miscible	very miscible
1:2.75	very miscible	very miscible	very miscible
1:3	very miscible	very miscible	very miscible
1:3.25	very miscible	very miscible	very miscible
1:3.5	very miscible	very miscible	very miscible
1:3.75	very miscible	very miscible	very miscible
1:4	very miscible	very miscible	very miscible
1:4.25	very miscible	very miscible	very miscible
1:4.5	very miscible	very miscible	very miscible
1:4.75	very miscible	very miscible	very miscible
1:5	very miscible	very miscible	very miscible

data that were provided for by numerous tests done previously during the early stages of the project. Can the oil of *C. luzonicum* start an engine of a motor vehicle? As pure oil can it run the vehicle? In the affirmative, would it be a smooth-running trip? And many more questions the answers to which were eagerly awaited in the hope that the search for the answers would end satisfactorily and successfully.

In the engine performance test using a ISUZU 240 motor vehicle, it was observed that: (1) Alone, *C. luzonicum* oil started the engine but only for a very brief duration; (2) a blend with diesel oil in the proportion one part *C. luzonicum* oil and one part diesel oil, and also one part *C. luzonicum* oil and two parts diesel oil started the engine bluish-white in color and had a pleasant, almost soothing odor.

The present study is only a preliminary investigation. It is highly desirable to do further studies most especially on engine performance tests and mechanical

Table 8. Some properties of the essential oil of *Canarium luzonicum* (Blume) A. Gray as compared with those of diesel oil, kerosene, and gasoline

	Oil of C. luzonicum	*Diesel Oil*	*Kerosene*	*Gasoline*
Heating value, Btu/lb	19,015	19,500	19,000	20,000
Flammability (seconds) 1.5 ml	36.6	did not burn alone	45	–
Illumination test 5.0 ml	3H, 10min	storm lamp was not lighted	2H, 40min	–
Volatility, %	69.17	19.81	99.97	99.92
Flash Point, °C	43.3	66	49	–
Corrosion (Cu strip)	slight tarnish	slight tarnish	slight tarnish	moderate tarnish
Gum content mg/100 ml	749	–	–	4

Table 9. Comparative characteristics of some common liquid fuels and the essential oil of *Canarium luzonicum* (Blume) A. Gray

FUEL	*°API*	*Specific gravity*	*Weight per gallon, lb*	*Initial B.P. °F*	*Endpoint °F*	*Gross heating value*
Gasoline[1]	65-56	0.720-0.755	5.99-6.28	85-105	300-435	20,000 Btu/lb
Kerosene[1]	45-40	0.802-0.825	6.68-6.87	340-360	500-550	19,000
Diesel Oil[1]	40-30	0.825-0.876	6.87-7.30	325-460	600-725	19,500
Crude Petroleum Oil[1]	57-10	0.751-1.000	6.25-8.70	....	....	19,000
C. Luzonicum Oil	34.016	0.8549	7.118	310-330	350-378	19,015

[1] Values corresponding to the common liquid fuels were adapted from F.R. Jones, "Farm Gas Engines and Tractors", 4th Ed., Mc Graw-Hill Book Co., Inc., New York. 1966, p. 148.

efficiency. Other parameters are also worth looking into to include: variations in the percentage yield of oil and chemical composition according to geographical distribution of the trees, experimental plantations under controlled conditions, effects of environmental conditions (soil, climate, etc.), keeping qualities of the oil, antioxidants if needed, effects on engines, tests on gasoline-fed motor vehicles, costing commercial possibilities and others.

Summary and Conclusions

The properties of the essential oil from the oleoresin of *Canarium luzonicum* (Blume) A. Gray were studied in order to determine whether or not the oil could be used as an alternative source of energy.

Standard fuel tests for which the oil was analyzed indicated its potentiality as a liquid fuel.

The oil showed a ASTM Distillation curve that placed it in the midrange of diesel oil and gasoline, signifying that the oil per se cannot be used as a substitute for diesel or gasoline.

In the engine performance test, the oil alone could not run the engine of a ISUZU 240 motor vehicle. However, feeding the vehicle with a blend of diesel in the proportion 1 part *C. luzonicum* oil and 3 parts diesel oil made the vehicle perform a smooth road test. The results indicate the possible use of the essential oil of *Canarium luzonicum* (Blume) A. Gray as a supplement to diesel oil in running a diesel motor vehicle. This finding is from a preliminary investigation; hence, further tests are needed to substantiate this initial observation.

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Lydia S. Crisostomo, Discussant

The paper presented certainly gave another possibility of utilizing plants as hydrocarbon sources, particularly for materials which may supplement diesel oil. The examination and evaluation of essential oil from *Canarium luzonicum* clearly indicate such possibilities. However, since the observations presented are still on a preliminary stage, further examination and evaluation should be done so that the combined results will give more workable knowledge. The complexity of the essential oils or their fractions from plant materials makes most tests have little value or may be misleading unless accompanied by other data. The stability of the materials should also be noted because saturated branched-chain hydrocarbons are far less stable than saturated straight-chain hydrocarbons and that olefinic hydrocarbons decompose more readily than saturated hydrocarbons.

The yield of the essential oil per tree is yet to be determined including the cost of production. It has been observed from other plant species that cost of production decreases as the plant mature with increase in yield. Calvin reports that for other plant species, yield could be improved dramatically by breeding and genetic selection and cited that there is a ten-fold increase in the yield of rubber plants during the 1950's and 1960's. Furthermore, there are plant species in the country which have high hydrocarbon properties and which have been utilized as fuels or illuminants.

The Bureau of Plant Industry has launched a progress to the planting of *Pittosporum resiniferum* Hems. or "Hanga" throughout the country anticipating its utilization as hydrocarbon source. Among other plant materials are the seeds of *Callophyllum inophyllum* commonly known as "bitaog" or "palomaria". The seeds yield 70-75% oil which have other uses such as for varnish and for tanning purposes. Notwithstanding is the mention of tree species whose trunks likewise been sources of oils, like the *Dipterocarpus, Gracilus* locally known as "apitong" and "panau", respectively. The oils separated from the sapwood have been investigated and they have also been earlier cited in the paper presented.

It is also known that *Canarium luzonicum* could also be a good source of food materials particularly as a source of proteins and fats. The study should therefore determine how the production of the essential oils would affect the production for food purposes. In this direction, a feasibility study should be conducted to determine the merit of the study, that is, to know which would cost more to produce, a liter of essential oil from *Canarium luzonicum* as supplement for diesel oil or a kilo of the fruit and nuts for food purposes.

Among other thing which should be considered if plant materials were to provide means of substituting or supplementing diesel products is the cost-benefit analysis of such utilization.

Knowing that the potential sources of petroleum-like products like diesel oils are perhaps, at this point, what should really be studied extensively is how these materials can reasonably be harnessed in meeting the high cost of the oils and its products.

Ronald Mendoza, Discussant

The tremendous drain in our country's dollar reserves which was accelerated by the oil crises in the past decade has focused attention to the internal combustion engine fuel. The transportation sector's share alone of the consumption of this fuel in 1975 was about 30%! If to this is added the utilisation of the fuel other than for transportation, by industry, we perceive that the development and production of an economically feasible, indigenous, internal combustion engine fuel to replace imported fuel would have a dramatic impact on the country's economic stability.

In this light, the study presented by Dr. Luz Oliveros-Belardo *et al.* on *Essential Oil of Canarium luzonicum (Blume) A. Gray as a Possible Supplement to Diesel Oil* is of timely relevance, and for this significant contribution towards easing the country's fuel problems, the authors deserve commendation.

The research of Dr. Belardo and her associates prompt the following points for consideration:

1. Comparison of the performance of various mix of *C. luzonicum* not only with diesel oil, but with kerosene, and other automative fuels like alcohol, and coco-oil.
2. A study of the problems of users particularly of motorists. The study might include among other things: corrosion, clogging of fuel lines, lack of power (particularly in acceleration, and in up-hill driving hard-starting, nitrous exhausts, hydrocarbon discharge and other pollution problems.
3. A search for additives which could alter the viscosity, volatility, and cetane index of *C. luzonicum* oil since the study strongly points out that if these properties could be modified, *C. luzonicum* oil could become suitable as a substitute rather than just as a supplement for diesel oil.
4. Fractional distillation of *C. luzonicum* oil, and blending of the various fractions in different proportions as the authors themselves pointed out could alter the properties of the oil so as to minimize problems like vapour lock, acceleration, and heating value.

To consider the economic viability of *C. luzonicum* as an indigenous fuel project, four criteria are offered:

1. *C. luzonicum* oil should cost less than any of the fuel it seeks to supplant.
2. It must perform with a minimum trade-off.
3. It must be capable of being produced locally in large volumes.
4. It should be processible in sitio.

For *C. luzonicum* oil to meet the above criteria, the following suggestions are offered:

1. Its raw material (the oleoresin) be processed right at the farms. This would minimize transportation in bulk resulting in decrease in the expenditure of labour and energy. Deterioration of the raw material is lessened thereby contributing to the enhancement of a better product quality. All of this would render the product more competitive.
2. Its distillation residuce should be studied for possible conversion to some by-products such as pharmaceutical products, and gums.
3. The acquisition and usage of household-type equipment should be encouraged. It is relevant to mention here that the metallic still designed by the authors for hydrodistillation is remarkable in its simplicity and economy.
4. Appropriate blend ratio and materials be encouraged.
5. An information campaign be launched touching among other things on:
   a. the development and utilisation of machineries which would utilise the community's raw materials and products to obviate siphoning off the community's income.
   b. the need for quality control.
   c. tax exemptions.