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PHILIPPINE EUCALYPTUS OIL

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TWO PLATES

Eucalyptus trees are native of Australia where they form about three-quarters of the vegetation of that continent. The eucalypts have been introduced into many other warm countries where they are now cultivated. Over three hundred species of eucalypts are known. These trees are evergreens and some of them occasionally reach a height of over 400 feet (122 meters). In Australia they are called gum trees, but the exudation from these trees is not really a gum but rather resembles an astringent tannin known locally as a kino. Eucalyptus trees are valuable for the rapidity of their growth, the usefulness of their timber, and the essential oils contained in their leaves.

Eucalyptus trees have been growing for some years in the highlands of the Philippines. Recently we distilled the leaves of various species of these eucalypts. When calculated on the weight of moist green leaves the yield of oil obtained varied from about 0.01 to 1.96 per cent. The highest yields of oil were obtained from *Eucalyptus globulus, E. tereticornis, E. polyanthemos,* and *E. citriodora.* Some of these trees gave over 4 per cent of eucalyptus oil calculated on a moisture-free basis. The quality and cineol content of oil obtained from *E. globulus* compared favorably with that of oil distilled from the same species in Australia.

26602

In Australia Baker and Smith [1] have carried out many investigations on the composition of oils obtained from numerous species of eucalyptus trees. Their results have shown that the essential oils obtained from different species may vary considerably in composition and also in yield. Oil obtained from a definite species grown in different localities usually has a comparatively constant composition. According to these authors, "this constancy of constituents must be taken into consideration in the diagnosis of doubtful species. Supposed allied forms that do not individually show chemical constituents in close agreement cannot consequently be the same species." Penfold [2] states that some eucalypts, such as certain varieties of *E. dives,* are so very much alike that they cannot be distinguished botanically according to morphological characteristics. They may be differentiated, however, by their distinctive individual leaf oils which differ in composition and physical properties.

Various eucalyptus oils are now used in the perfumery industry for scenting soaps and for similar purposes. Some oils which contain phellandrene and piperitone are employed in mineral separation by the flotation process. Eucalyptus oils are also used in certain pharmaceutical preparations and also for the manufacture of cheap disinfectants. The germicidal values of various pure constituents in some of these oils have been found to have high Rideal-Walker coëfficients varying from about 5 to 22.

The pharmacopœias of the United States and other countries specify the oil of *Eucalyptus globulus* as official and require a high cineol (eucalyptol) content because the medicinal value of eucalyptus is generally supposed to depend upon the amount of cineol contained in the oil. However, it is doubtful if the value of the oil really depends only on the cineol content for, according to Penfold,[3] the medicinal properties of eucalyptus were founded originally upon those oils which did not contain cineol. Only small quantities of oil from *E. globulus* are now distilled in Australia as there are other eucalypts, such as *E. australiana,* which give much higher yields.

There are a number of eucalyptus trees growing at Baguio, a summer resort situated at an elevation of about 1,500 meters

[1] The Eucalypts and their Essential Oils, Sydney Technological Museum Education Series 24 (1920) 7 and 11.

[2] Journ. Chem. Ed. 9 (1929) 1196.

[3] Journ. Chem. Ed. 6 (1929) 1196.

in the mountain province of the Philippines. The forester, S. Laraya, in charge of the forestry nursery at Baguio estimates that there are now about 5,000 eucalyptus trees in Baguio and the vicinity. These trees are located approximately as follows:

Location.	Estimated number of trees.
Forbes Park	600
Baguio City	3,000
Busol Forest Reserve	400
Camp 8 Plantation, Benguet Road	200
Lucban Hill Plantation	500
Santo Tomas Trail Plantation	300

They range in height from about 2 meters for the younger trees to about 23 meters for the older ones. As usual with eucalyptus the leaves of these trees were found to be in excellent condition and not infected with any kind of fungus growth.

EXPERIMENTAL PROCEDURE

During the spring of 1929 we decided to investigate the oil content of Philippine eucalyptus trees. Through the courtesy of the Commanding Officer of Camp John Hay we obtained permission to use the plumber's shop at this military post as a field laboratory. The army officers very kindly provided us with electric lights and laboratory tables. All necessary chemical supplies and equipment were transported from the Bureau of Science in Manila to this field laboratory in Baguio.

The trees selected for our investigation were numbered, and a metal label containing the number was attached firmly to each tree for future identification. The data concerning these trees are recorded in Table 1, which gives the number of each tree, name, approximate location, and conditions of growth, such as height and position (shady or sunny) on hillside or elsewhere. As shown by the data (Table 1), we selected for our investigation eucalyptus trees of various sizes and growing under different conditions.

In Baguio, during the late springtime, afternoon and evening showers occur frequently. The moisture content of moist, damp eucalyptus leaves gathered early in the morning is greater than that of leaves gathered later in the day when the sun is overhead and the temperature is much higher than in the early morning. If the oil content of the leaves is calculated on the weight of the green leaves then, due to the moisture present, the percentage of oil in leaves from the same tree will vary according to when the leaves are gathered, whether in the early morn-

TABLE 1.—*Location and description of Philippine trees selected for distilling eucalyptus oil.*

Tree No.	Location.	Height.	Position.	Light.	Species.
		Meters.			
	Forest nursery:				
31-A	South of office	14	Level land	Sunny	*E. robusta.*
31-C	Opposite office	16	do	do	*E. globulus.*
31	Road to Bureau of Agriculture Experiment Station	2.5	do	do	Do.
31-D	Do	9	do	Half shady	*E. tereticornis.*
31-E	Do	17	do	Sunny	Do.
31-F	Do	10	do	do	Do.
32-A	Do	7	do	do	*E. polyanthemos.*
32	East of office	3.5	do	do	Do.
33	Do	18	do	do	*E. viminalis.*
34	Do	10	do	Half shady	*E. pulverulenta.*
35	Back of office	20	do	do	*E. tereticornis.*
36	Do	22	do	do	*E. viminalis.*
37	Do	22	do	do	Do.
38	West of office	20	do	Sunny	*E. robusta.*
39	Junction of Leonard Wood Road and Gibraltar Road	13	do	Half shady	*E. globulus.*
	Session Road:				
40	Near Military Circle	11	do	Sunny	*E. corymbosa.*
40-A	Do	10	do	do	Do.
40-B	Do	11	do	do	Do.
41	Do	13	do	Half shady	*E. saligna.*
42	Near City Ice Plant	12	do	Sunny	*E. corymbosa.*
43	Do	13	do	do	*E. melliodora.*
45	Do	12	do	do	*E. crebra.*
44	Below Quezon Cottage	20	do	Half shady	*E. saligna.*
54	Crossing of Session Street at Japanese Bazar Garage	11	Hillside	Sunny	*E. paniculata.*
46	City Ice Plant Road	10	Level land	Half shady	*E. hemiphloia.*
47	Do	20	do	Sunny	*E. citriodora.*
48	Do	22	do	do	*E. rostrata.*
49	Near Cottage No. 6	11	do	Half shady	*E. paniculata.*
50	Do	23	do	Sunny	*E. saligna.*
64	East of City Ice Plant Building	12	do	Shady	*E. pilularis.*
	Luneta Hill:				
51	Opposite University Building	10	Hilltop	Sunny	*E. globulus.*
52	Luneta hillside	3	do	Half shady	*E. citriodora.*
52-A	Opposite Vallejo Hotel	10	Hillside	do	Do.
	Pack Road:				
53	Side of Baguio Chamber of Commerce Building	15	Hilltop	Half shady	*E. pulverulenta.*
53-A	Do	14	do	do	Do.
55	Side of Japanese School Building	20	Level land	Sunny	*E. stuartiana.*
55-A	Do	16	do	do	Do.
56	Do	11	do	do	*E. pulverulenta.*

TABLE 1.—*Location and description of Philippine trees selected for distilling eucalyptus oil*—Continued.

Tree No.	Location.	Height.	Position.	Light.	Species.
		Meters.			
57	City Hill Park	7	Level land	Half shady	*E. melliodora.*
	Busol Forest Reserved Plantation:				
58	Near Laborer's Camp Cottage	10	Hillside	Sunny	*E. robusta.*
59	Above the Creek	10	do	Half shady	*E. saligna.*
60	Road to Laborer's Camp	2	do	Sunny	*E. globulus.*
	Forbes Park No. 2:				
61	Near bridge trail	7	Level land	Shady	*E. microcorys.*
62	Below Teacher's Camp	13	do	Half shady	*E. siderophloia.*
63	Do	13	do	do	*E. microcorys.*

ing or at noon. In order to have a definite standard for comparison it would seem that the oil content of the leaves should be calculated on a moisture-free basis. It should make practically no difference then at what time of the day the leaves are gathered as leaves from the same tree should always give approximately the same oil content.

When the usual method for determining moisture was employed, the eucalyptus leaves naturally lost not only moisture but also the volatile eucalyptus oil. When the crushed leaves were heated in an oven (100° C.) to a constant weight the dried residue consisted of nonvolatile solids and usually contained also small quantities of nonvolatile oils. The dried residue had only a very slight odor and, when distilled with water, only a very small quantity of oil was found to be in the distillate although the distillate had a rather strong odor quite unlike cineol. When the dried residue from a quantity (25 grams) of crushed leaves was distilled, the ether extract of the distillate gave only 0.0016 gram of oil.

In calculating the results of our experiments we have based our calculations both on the weight of moist green material and also on a moisture-free basis. Our experimental procedure was as follows: A quantity of eucalyptus leaves from a particular tree was ground in a meat grinder. The pulp was mixed thoroughly and a sample (100 grams) treated with water and distilled about two hours. According to our experiments this is a sufficient length of time to remove practically all the volatile oil from 100 grams of leaves. The eucalyptus oil was obtained from the aqueous distillate by extracting with ether. The ether

extract was then dehydrated with sodium sulphate, filtered, and the ether removed by distilling on a water bath.

For the moisture determination a sample of ground leaves (2 grams) was heated in an oven at a temperature of 100° C. to constant weight. This required usually about eighteen hours. The loss in weight represented the moisture and volatile oil. The residue consisted of nonvolatile solids together with a small quantity of nonvolatile oil. The results were calculated on the basis of 100 grams of leaves. The following notes give a summary of one of our experiments:

100 grams of moist green eucalyptus leaves distilled gave 1.62 grams of eucalyptus oil.

100 grams of leaves dried to constant weight gave a loss in weight of 62.57 grams.

100.00 grams of eucalyptus leaves.
62.57 moisture and volatile oil in 100 grams of leaves.
37.43 nonvolatile solids and nonvolatile oil in 100 grams of leaves.

62.57
1.62 volatile oil.
60.95 moisture.

100.00
60.95
39.05 volatile oil, nonvolatile oil, and nonvolatile solids in 100 grams of moist green leaves.

$\frac{1.62 \times 100}{39.05} = 4.15$ per cent of volatile eucalyptus oil calculated on a moisture-free basis.

Analysis of eucalyptus leaves calculated on the weight of moist, green leaves would then be as follows:

	Per cent.
Eucalyptus oil	1.62
Nonvolatile oil and solids	37.43
Moisture	60.95
Total	100.00

The oil in Philippine eucalyptus trees, as in eucalypts grown elsewhere, seems to be located almost entirely in the leaves, for when the wood and branches of Philippine trees were distilled only traces or very small amounts of oil were obtained. For the few trees investigated the results given in Table 2 indicate

that large leaves of individual trees contained more oil than small leaves. Some trees have both elongated and rounded leaves. The rounded leaves appeared to contain a slightly larger proportion of oil than the elongated leaves.

TABLE 2.—*Eucalyptus oil in different kinds of Philippine eucalyptus leaves.*

Tree No.	Height of tree.	Kind of leaf.	Analysis.			
			Moisture.	Nonvolatile oil and solids.	Eucalyptus oil in green leaves.	Eucalyptus oil calculated on moisture-free basis.
	Meters.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
31	2.5	Small	72.18	27.01	0.81	2.91
31	2.5	Large	65.75	32.53	1.72	5.02
39	13	Small	64.71	34.67	0.62	1.76
39	13	Large	60.90	38.10	1.00	2.57
47	20	Small	63.73	34.98	1.29	3.56
47	20	Large	57.72	40.32	1.96	4.64
31–B	20	Rounded	53.12	45.02	1.86	3.97
31–B	20	Elongated	52.61	45.79	1.60	3.38
31–C	16	Rounded	56.00	43.01	0.99	2.25
31–C	16	Elongated	56.26	42.95	0.79	1.81

As there are a number of species of eucalyptus trees in the Philippines our present investigation consisted principally in distilling the leaves of these various eucalypts in order to determine which species gave the highest yields. The results are recorded in Table 3.

As shown by the results the leaves of Philippine eucalyptus trees gave, in general, only a small percentage of essential oil. A few of the trees, however, gave yields of more than 1.5 per cent calculated on a moisture basis. The data (Table 3) show also the difference between calculating the yield of eucalyptus oil on the weight of moist, green leaves and on a moisture-free basis. When calculated on the weight of moist, green material, the leaves of trees 53 and 32–A gave approximately the same yield of oil. When calculated on a moisture-free basis the leaves of tree 53 gave a much higher yield of oil (3.06 per cent) than the leaves of tree 32–A (2.48 per cent). Since other analyses (Table 3) gave the same kind of results, it would seem that the correct standard for comparing the oil content of different trees would be to make the calculation on a moisture-free basis.

TABLE 3.—*Eucalyptus oil in mature leaves of Philippine eucalyptus trees.*

Tree No.	Height of tree.	Analysis.			
		Moisture.	Nonvolatile oil and solids.	Eucalyptus oil in green leaves.	Eucalyptus oil calculated on moisture-free basis.
	Meters.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
31-A	14	57.75	42.20	0.05	0.12
31-D	9	55.96	42.54	1.50	3.41
31-E	17	58.37	40.70	0.93	2.23
31-F	10	60.95	37.43	1.62	4.15
32	8.5	53.06	45.33	1.61	3.43
32-A	7	56.40	42.52	1.08	2.48
33	18	60.93	38.61	0.46	1.18
34	10	55.98	43.48	0.54	1.23
35	20	61.77	37.57	0.66	1.73
36	22	61.67	37.58	0.75	1.96
37	22	58.35	41.26	0.39	0.94
38	20	54.36	45.60	0.04	0.09
40	11	51.73	48.21	0.06	0.12
40-A	10	51.99	47.93	0.08	0.17
40-B	11	54.25	45.65	0.10	0.22
41	13	60.32	39.54	0.14	0.35
42	12	56.01	43.98	0.01	0.02
43	13	60.29	39.53	0.18	0.45
44	20	63.80	36.15	0.05	0.14
45	12	66.04	33.65	0.31	0.86
46	10	67.17	32.10	0.73	2.22
48	22	58.07	41.86	0.07	1.70
49	11	64.19	35.52	0.29	0.81
50	23	68.54	31.42	0.04	0.13
51	10	62.24	36.15	1.61	4.26
52	3	59.27	39.08	1.65	4.06
52-A	10	59.04	39.16	1.80	4.39
53	15	65.74	33.21	1.05	3.06
53-A	14	64.62	34.62	0.76	2.15
54	11	64.55	35.30	0.15	0.42
55	20	59.88	39.67	0.45	1.12
55-A	16	59.92	39.82	0.26	0.65
56	11	57.37	41.56	1.07	2.51
57	7	55.47	44.16	0.37	0.83
58	10	44.40	55.44	0.16	0.29
59	10	53.21	46.64	0.15	0.32
60	2	48.28	50.96	0.76	1.47
61	7	57.52	42.31	0.17	0.40
62	13	54.85	44.32	0.83	1.84
63	13	58.44	41.21	0.35	0.84
64	12	59.82	39.83	0.35	0.87

Data on Philippine trees which gave the highest yields of eucalyptus oil are given in Table 4. By careful cultivation of these particular species of eucalypts it might be possible to produce trees which would give much higher yields of oil.

Possibly, if these species were cultivated in other parts of the Philippines where the soil conditions are different the yield of oil might be larger than in Baguio.

TABLE 4.—*Philippine trees which gave the highest yields of eucalyptus oil.*

Tree No.	Location.	Height.	Species.	Yield of eucalyptus oil.	
				Calculated on weight of moist green leaves.	Calculated on a moisture-free basis.
		Meters.		*Per cent.*	*Per cent.*
	Forest nursery:				
31	Road to Bureau of Agriculture Experiment Station	2.5	*E. globulus*	1.72	5.02
31-B	Opposite office	20	do	1.86	3.97
	Luneta Hill:				
51	Opposite to University Building	10	do	1.61	4.26
	Forest Nursery:				
31-D	Road to Bureau of Agriculture Experiment Station	9	*E. tereticornis*	1.50	3.41
31-F	Do	10	do	1.62	4.15
32	East of office	3.5	*E. polyanthemos*	1.61	3.43
47	City Ice Plant Road	20	*E. citriodora*	1.96	4.64
	Luneta Hill:				
52	Luneta hillside	3	do	1.65	4.06
52-A	Opposite Vallejo Hotel	10	do	1.80	4.39

Baker and Smith [4] report that in Australia the yield of essential oil from *E. australiana* varies from 2.5 to 3.3 per cent depending on the season, and one sample of leaves which was somewhat dry gave a yield of 4.4 per cent. These yields are usually high and much greater than those obtained from any of the Philippine eucalypts which we have investigated. However, when calculated even on a moisture basis, the yields in Australia from *E. globulus* (0.92 per cent), *E. tereticornis* (0.50 per cent), *E. polyanthemos* (0.83 per cent), and *E. citriodora* (0.85 per cent) were very much less than the corresponding yields (1.50 to 1.96 per cent) which we obtained in the Philippines for these particular species. When calculated on a moisture-free basis our yields for these species were very high. Some trees gave an oil content of more than 4 per cent.

As *Eucalyptus globulus* is, perhaps, one of the most widely known species of eucalypts we distilled a quantity of this oil in order to determine the constants and quality of it. This oil

[4] The Eucalypts and their Essential Oils, Sydney Technological Museum Education Series 24 (1920) 171, 165, 208, 99, and 115.

which had a light amber color and a rather intense cineol odor, was found to have the following constants:

Specific gravity ($d \frac{30° C.}{30° C.}$), 0.9189

Refractive index ($N \frac{29° C.}{D}$), 1.4636

Specific rotation ($A \frac{30° C.}{D}$), +5.06

The cineol content of the oil from *E. globulus* was determined according to the methods given by Baker and Smith.[5] The pharmacopœia preliminary test indicated a cineol content of about 80 per cent. The rapid phosphoric acid-petroleum ether method gave a cineol content of 60 per cent.

SUMMARY

We have investigated several species of eucalyptus trees growing at Baguio, in the highlands of Luzon, Philippine Islands. These trees were of various sizes and growing under different conditions. The results of our experiments have shown that in these Philippine trees the eucalyptus oil is located almost entirely in the leaves for when the wood and branches were distilled only traces or very small amounts of oil were obtained.

The particular species which gave the highest yields of eucalyptus oil were *E. globulus*, *E. tereticornis*, *E. polyanthemos*, and *E. citriodora*. These eucalypts gave higher yields of oil in the Philippines than in Australia. The leaves of some of these trees gave yields of over 4 per cent calculated on a moisture-free basis. The yield of oil was also calculated on the weight of moist green leaves but, as shown by our figures, the results are apt to be misleading due to the variable amount of moisture contained in the leaves.

The constants and cineol content of the oil obtained in the Philippines from *E. globulus* were found to compare favorably with similar data on the oil distilled from the same species in Australia.

[5] Op. cit. 364.

ILLUSTRATIONS

PLATE 1. PHILIPPINE EUCALYPTUS TREES IN BAGUIO.

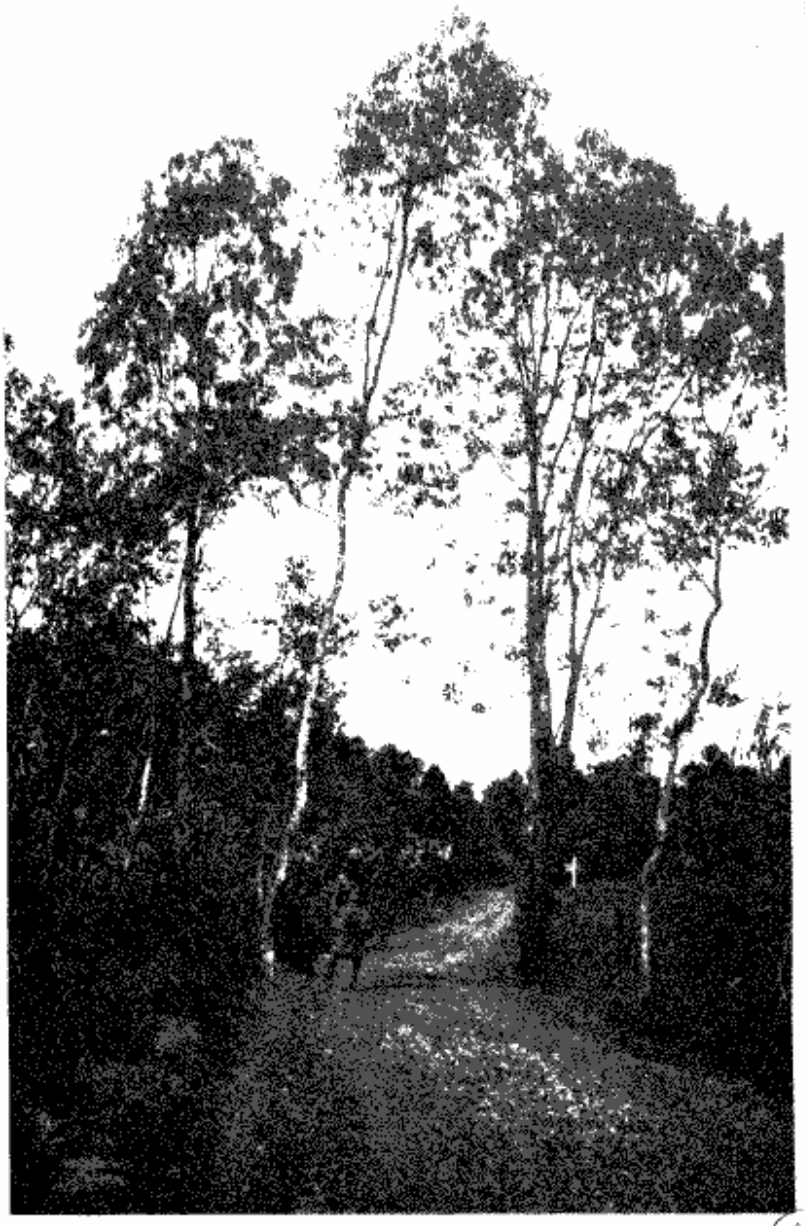

PLATE 2. PHILIPPINE EUCALYPTUS TREES IN BAGUIO.