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Development of Efficient System for Extracting Oil from Scrap Woods of Aomori Hiba

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Using scrap woods of aomori hiba, we developed a consecutive industrial extracting system allowing for efficient and low cost oil extraction. The content of hinokitiol tends to increase with extracting time in hiba oil. Further, we found that the oil extracted from the sawdust of lumbering contains a higher percentage of hinokitiol as compared with that extracted from the sawdust of the powdering machine. However, in the case of powdered sawdust, that of a particle size greater than 1.2 mm resulted in highest extraction yield.

1. INTRODUCTION

Aomori hiba, together with kiso hinoki and akita sugi, is one of Japan's three principal tree types, and has a lifespan of up to 200 years, reaching a height of up to 30 meters and a diameter of up to 150 centimeters. The total resources of aomori hiba are 16,130,000 cubic meters, with aomori having approximately 82% of that total. The reason Aomori hiba is very resistant to rot and decay is due to the hiba oil contained in its core. With a steam distillation process, the scrap waste component of approximately 1% is extracted, however, with this process, pulverization of the material is necessary.

Up to this point, the equipment and materials used in refining of hiba oil were made of iron, thus the resulting in hinokitiol with a red-brown coloration, for which demand has not risen. However, with use of an extraction tank constructed of thick hiba planks, the result in which no coloration occurred could be obtained, thus increasing hinokitiol's potential use.

In this paper, with the objective of increasing the efficiency of hiba oil extraction, particularly regarding the efficient use of hiba resources and time for hinokitiol extraction, and investigation of hiba oil extraction was undertaken.

2. EXPERIMENTAL METHOD

2.1. Experimental equipment

The experimental equipment system used is shown in Fig. 1. The small scale equipment consisted of a boiler with an output of 48W, where at one hour, 57 kg of steam are produced. In the case of the large

extraction equipment, a Miura Factory QUNOL NR-300 boiler, with a capacity of 2.0 m^3 with real treatment potential of 400 kg and steam amount of 300 kg/h was used.

2.2. Measurement of hinokitiol in hiba oil

Measurement of hinokitiol was conducted with the HPLC method. The machine used was a Shimazu System Control SCL-6A, Chromatograph LC-6A High Speed Liquid Chromatograph, together with a Shimazu C-R4A Chromatpac Data analyzer. The resulting data is shown in Table 1.

Analysis of the content of hinokitiol in the hiba oil was carried out by the absolute working curve method, because the impurity peak was detected at the same retantion time of the internal standard.

The internal standard solution was prepared by dissolving 100 mg of dimethyl terephthalate in 50 ml of acetonitrile.

The hinokitiol solution was prepared by dissolving 100 mg of hinokitiol in 50 ml of acetonitrile, and adding distilled water up to 100 ml. The hinokitiol standard solution was prepared by 5 ml of the hinokitiol solution and 5 ml of the internal standard solution in 100 ml of measuring flask, and adding eluent (10mM KH_2PO_4 - 1mM EDTA 2Na / Acetonitrile = 60 / 40) up to 100 ml.

The hiba oil solutions were prepared by dissolving 100 mg of hiba oil in 50 ml of acetonitrile, and adding distilled water up to 100 ml. The samples of hiba oil were prepared by 5 ml of the hiba oil solution and 5 ml of the internal standard solution in 100 ml of measuring flask, and adding eluent up to 100 ml.

3. RESULTS AND DISCUSSION

3.1. Relation of extracted component and hinokitiol amount

Investigation of the hinokitiol amount in the extracted hiba was done on the base part of the hiba and compared with the amount of hinokitiol. Using the small equipment, the change in content with extraction over time for hiba root oil as well as hiba root in distilled water is shown in Table 2.

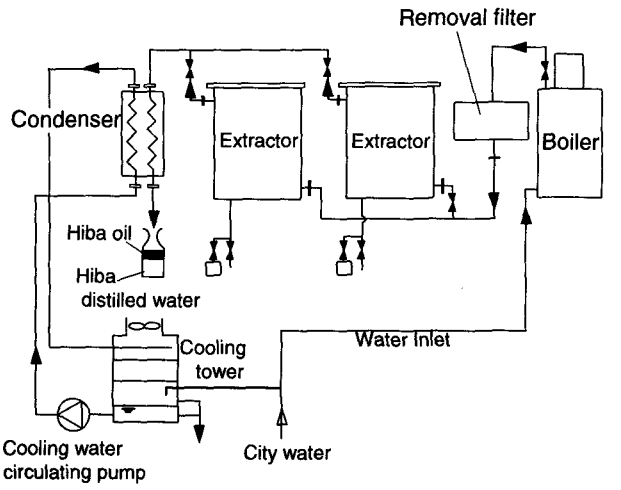


Fig.1 The extraction system of hiba oil.

Table 1 Analytical conditions of hinokitiol.

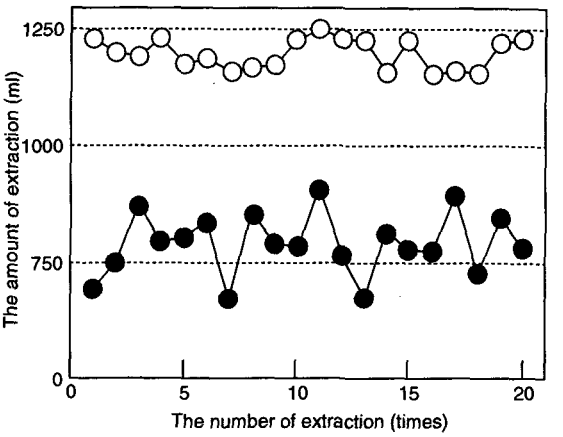
Column	150X4.6mm
Packing material	Inertsil C4 5μ
Eluent	10mM KH_2PO_4-1mM EDTA2Na / CH_3CN = 60 / 40
Flow rate	1.0 ml /min
Detector	UV 254 nm
Column temperature	Ambient

In the case of hiba root in distilled water, with a hinokitiol level of 45 ppm at 45 minutes extraction time, this is a small amount. However, with increased time, the amount of hinokitiol extracted increased. Comparing hiba root oil with hiba woody oil, the oil extracted from the root was up to four times the amount extracted from the wood. Further, the hiba extracted from the hiba root in distilled water was twice that extracted from hiba wood in distilled water.

3.2. Hiba extracted with change in situation

Extraction amounts were measured with varying conditions of extraction. In the case of the small equipment extraction, as shown in Table 3, the first and second trials were conducted under normal conditions, with the third done with half the amount of sawdust and the fourth conducted with a raised cooling output temperature.

In the case of normal condition results, the amount collected after the first hour was the maximum, after which the amounts decreased steadily. However, with half the sawdust amount, the maximum extraction amount was found at thirty minutes. Lastly, with a higher outlet cooling temperature, the extraction pattern was similar to, but yielded less than trial numbers 1 and 2.



○: Sawdust of lumbering,
●: Sawdust of podering machine,
The amount of sawdust used : 100 kg at a time.

Fig.2 The yield of hiba oil extracted from the sawdust of lumbering and the sawdust of powdering machine.

Table 2 The content of hinokitiol extracted from aomori hiba.

Sample	Extraction time elapsed (min)	The content of hinokitiol
Hiba root oil	0 - 45	2.51 %
	45 - 90	2.22 %
	90 - 135	3.00 %
	135 - 180	4.02 %
Hiba woody oil	45 - 90	0.51 %
Hiba root distilled water	0 - 45	45.0 ppm
	45 - 90	90.2 ppm
	90 - 135	106.7 ppm
	135 - 180	125.4 ppm
Hiba woody distilled water	45 - 90	63.0 ppm

Table 3 Extraction test of hiba oil at various conditions

No.	The amount of sawdust used (kg)	Cooling temp. (°C) Inlet	Outlet	The amount of cooling water (L)	The quantity of electricity (kW)	The amount of extraction (ml) 0.5	1.0	1.5	2.0	2.5 (hour)
1	10	7	30	124.5	10	--	40	28	18	6
2	10	7	30	124.5	9	10	44	22	12	--
3	5	7	30	124.5	6	22	18	7	--	--
4	10	7	90	34.5	6	6	26	12	--	--

3.3. Comparison of hiba oil extraction using lumbering sawdust versus powdered sawdust

Extraction amounts were measured for sawdust generated both by lumbering and by a powdering machine. The extraction test was conducted on a large extraction machine, with 20 extractions using 100 kg of sawdust at a time. These results are shown in Fig. 2.

In the case of sawdust from lumbering, with each extraction, a yield of between 1,210 and 1,280 ml of hiba oil was obtained, with an average of 1,230 ml. On the other hand, in the case of powdered sawdust, the results ranged from 700- 950 ml of hiba oil, with the average being 818 ml. Hiba oil is found in the core of the tree, therefore extraction amounts from the powdering machine are lower than those for the case of lumbering.

3.4. Comparison of hiba oil in powdered sawdust

Regarding the extraction of hiba oil from powdered sawdust, an investigation of variation with particle size was undertaken. The three sizes were large (over 1.2mm), medium (from 0.3-0.6 mm), and small (less than 0.2mm), with extraction based on 100 kg amounts of each. The results averaged 12.5 ml of hiba oil extracted for the large particle size, 9.3 ml for the medium size, and 6.0 ml for the small particle size, and thus the larger sized particle yielded more oil. In the case of the small sized particles, the overall particle spacing density does not allow the steam to flow uniformly throughout and within the particles.

4. CONCLUSION

With the goal of increasing extraction efficiency for hiba oil containing hinokitiol, we investigated variations of time and particle size with the following results.

(1) For both hiba root oil and hiba wood oil, an increase in extraction time lead to increase amount of hinokitiol.

(2) Comparing lumbered sawdust and powdered sawdust, hiba oil extraction from powdered sawdust was greater.

(3) Concerning the particle size of the powdered sawdust, particles of over 1.2mm proved to be most efficient for extraction. Further, in the case of small particle size, the spacing density proved to be the inhibitor for effective result.