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Control of Inhibitory Effects of Sugi, Hinoki Barks on Plant Growth

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Quantities of water extractives or methanol extractives from the barks of sugi and hinoki were largely different from sample to sample and were closely related to the growth inhibition of annual plants when the plants were grown in their bark media. Cucumber and eggplant seeds were used for these experiments. They were germinated and grown on wet absorbent cotton containing each extractive in the Petri dish. The plant growth was apparently depressed according to the increase of the extractives, especially the inner bark was markedly abundant in the extractives and influenced more than the outer bark. There was little difference of inhibitory effect between sugi and hinoki bark extractives. Higher molar phenolic substances, such as flavanol derivatives and condensed tannins seem to be main cause, therefore these problems are assumed to be alleviated if the solubility of such phenols is lowered. Addition of gelatin or cationic polymers was found to dramatically reduce the plant growth inhibition and some kinds of water-soluble polymers were also effective to solve these problems.
Key words: sugi, hinoki, bark extractives, agricultural use, growth inhibition

1. INTRODUCTION

A huge quantity of sugi (*Cryptomeria japonica* D. Don) and hinoki (*Chamaecyparis obtusa* Endl.) barks is generated every year, but their incineration as a traditional disposition method has recently been prohibited by legislation. Therefore forest and lumber industries are in difficulty to dispose them and are searching new and large-scale utilization. One of their promising uses is for the agricultural ones, e.g. compost, pot medium, mulch etc, but some extractives contained in these barks have been reported to impede the growth of plants [1,2]. However, our preliminary experiments showed that these results were not always able to be reproduced. Its reason is supposed to be originated from the difference of bark samples. Therefore, bark samples with distinct origins were investigated to precisely clarify the relationships between their extractives and plant growth inhibition. Furthermore, some experiments for alleviating this inhibition effect were conducted.

2. EXPERIMENTAL

Sugi and hinoki barks were obtained from wood processing company and different ages of woods from Kochi University Forest. Each bark except ones from wood processing company was separated by hand into inner and outer barks. All barks were pulverized, and the bark powder passed through 16 mesh of screen was extracted with 60℃ and 90℃ of hot water for one hour, respectively. The combined extractives are called as water extractives. On the other hand, bark powder was also dewaxed two times with benzene and the resulting powder was further extracted for 8 hours with methanol by Soxhlet apparatus. The former is called as benzene extractives, and the latter as methanol extractives. Total flavanol and tannin contents in these water extractives and methanol extractives were determined by the conventional methods [3]. The fixed quantities of benzene extractives or methanol extractives were added to 0.5g of absorbent cotton placed in 9cm diameter of Petri dishes and the solvents were removed with vaporization. Cucumber and eggplant seeds were placed onto the cotton wetted with 10ml of distilled water. These Petri dishes were placed in the oven and the temperature was kept at 25℃. The growths of stems and roots were measured everyday, and five sets of trials were done for every test and the data were averaged.

Some chemicals, such as gelatin, polyvinyl pyrrolidone (PVP), casein, polyethylene glycol (PEG) etc. were added into the cotton with bark extractives and the growth of cucumber was measured as mentioned above.

3. RESULTS AND DISCUSSION

The ratios of inner and outer barks are shown in Table 1. The inner bark contents are higher in young trees than in old trees, and also higher in hinoki than in sugi. But, 32 years old sugi tree had high outer bark contents, it should

be considered that the ratios of inner and outer bark contents are sometimes influenced by the samples.

Table 1 The ratios of outer and inner bark contents of different ages of sugi and hinoki.

	Sugi		Hinoki	
	Outer bark	Inner bark	Outer bark	Inner bark
18 years old	53	47	46	54
32 years old	72	28	55	45
45 years old	64	36	58	42

(% to the total bark)

Water extractive contents are shown in Table 2. Inner barks contain water extractives much larger than outer barks, especially in the case of fresh barks from 32 years old of sugi, and 18 and 32 years old of hinoki. Outside storage of felled wood for half year decreased the extractive contents slightly for the outer barks and largely for the inner barks. It means that the water extractive contents of inner barks are quite large but easy to receive heavy losses during storage period. Barks from wood processing company could not be separated into inner and outer barks, and exact time passed after felling woods was unknown. They are assumed to be stored outside for more than half year and are rich in outer barks because the water extractive contents are low, mostly similar to those of outer barks.

Table 2 Water extractive contents of sugi and hinoki barks.

	Sugi		Hinoki	
	Outer bark	Inner bark	Outer bark	Inner bark
18 years old	3.12	7.80	1.97	16.56
32 years old	2.47	15.98	2.28	15.83
32 years old *1)	2.19	6.38	1.98	3.79
Bark A *2)	3.17		1.46	
Bark B *2)	3.20		3.23	

(% to the bark)

*1): Woods which had been left in the forest for half year after felling

*2): Barks from wood processing company

Benzene extractive contents were relatively low and were in the range from 0.5 to 2%.

Methanol extractive contents are shown in Table 3. Every content value is higher than that of water extractives and shows quantitative tendency similar to that of water extractive content shown in Table 2. For the fresh barks, hinoki has methanol extractive contents larger than sugi, but adversely sugi has larger than hinoki for the aged barks. It means that extractives from hinoki barks are liable to decrease more than those from sugi barks.

Table 3 Methanol extractive contents of sugi and hinoki barks.

	Sugi		Hinoki	
	Outer bark	Inner bark	Outer bark	Inner bark
18 years old	4.42	9.30	5.25	21.77
32 years old	4.45	18.40	5.99	22.80
45 years old	4.39	20.14	6.22	28.49
32 years old *1)	4.13	8.54	4.05	5.71
Bark A *2)	4.73		3.84	

(% to the bark)

*1): Woods which had been left in the forest for half year after felling

*2): Barks from wood processing company

The inner barks from sugi and hinoki are abundant in condensed tannin [3], which is composed of proanthocyanidins, 4-8 linked flavanol monomers, catechin or epi-catechin [4]. Total flavanol and tannin contents in the methanol extractives are shown in Fig. 1. Total

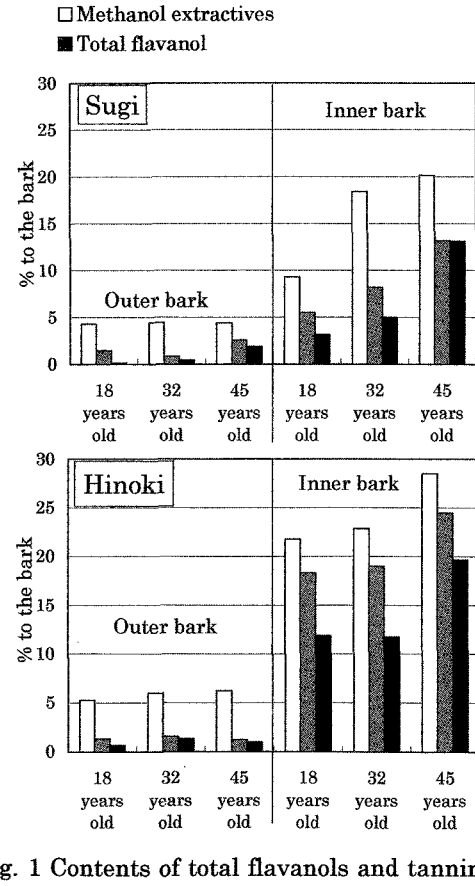

Fig. 1 Contents of total flavanols and tannins in methanol extractives from sugi and hinoki barks.

flavanols and tannins changed in proportion to the methanol extractive contents. Inner barks contain much larger amounts of flavanols and tannins. Ratios of total flavanol contents to methanol extractive contents are higher in the inner barks than in the outer barks, and higher for hinoki than for sugi. Total flavanols of hinoki inner barks amounted to 80 % of methanol extractives. Older the tree ages are, higher the ratios of tannins to total flavanols are for both sugi and hinoki barks. High molar phenolics, condensed tannins are increased according to increase of tree ages.

Growth of cucumber in the media with methanol extractives from sugi or hinoki inner and outer barks are shown in Fig. 2 to Fig. 5.

Daily changes of root and stem lengths in the media with methanol extractives from only sugi inner barks are illustrated in Fig. 2 and Fig. 3, respectively, because daily growth in the media with the other methanol extractives from sugi outer, hinoki inner and outer barks showed tendency similar to that in Fig.2 and Fig.3. Root and stem growths are largely inhibited in the media with more than 4% of methanol extractives.

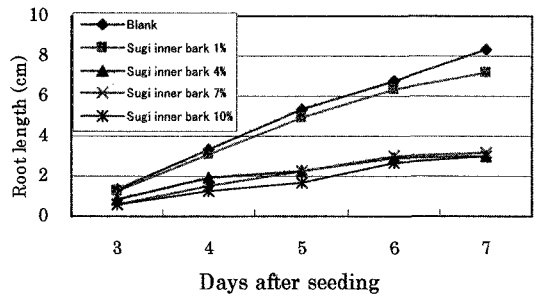

Fig. 2 Growth of cucumber roots in the media with methanol extractives (0-10%) from sugi inner barks.

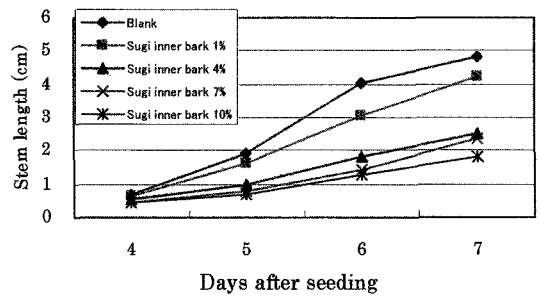

Fig. 3 Growth of cucumber stems in the media with methanol extractives (0-10%) from sugi inner barks.

Root and stem lengths at 7 days after seeding are shown in Fig. 4 and Fig. 5. In the media containing 4% of methanol extractives from sugi and hinoki outer barks, growth of cucumber decreased to about two third of the growth of the blank test. In the case of inner barks, growth decreased to less than half of that of the blank test. Inner bark extractives influence the plant growth stronger than outer bark extractives. As methanol extractive contents are also extremely large in the inner bark, inner bark must be crucial for inhibitory effects of sugi and hinoki barks on plant growth. Figs. 2-4 indicates that root and stem lengths in the media with 7 and 10 % of methanol extractives are mostly similar to those with 4 %, but roots and stems are badly distorted when larger amount of extractives are added into the media.

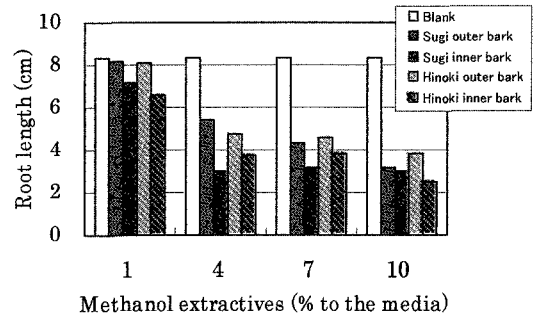

Fig. 4 Root lengths of cucumber grown in the media with methanol extractives from sugi and hinoki barks at 7 days after seeding.

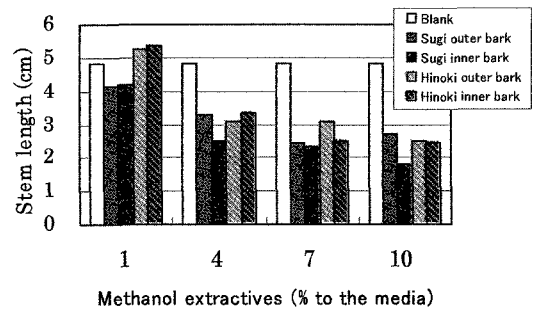

Fig. 5 Stem lengths of cucumber grown in the media with methanol extractives from sugi and hinoki barks at 7 days after seeding.

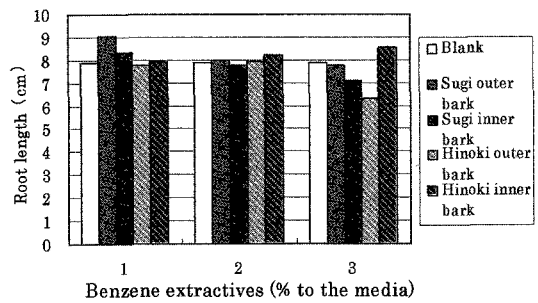

Fig.6 Root lengths of cucumber grown in the media with benzene extractives from sugi and hinoki barks at 7 days after seeding.

Effects of benzene extractives from sugi or hinoki inner and outer barks on cucumber growth are shown in Fig. 6. Although 3% of

benzene extractives show detrimental effects slightly, benzene extractive contents are less than 2%, therefore, they affects the plant growth very little.

Methanol extractives from sugi, and hinoki barks are being further investigated, then the details about inhibitory substances etc. will be published elsewhere.

As mentioned above, major components for inhibitory effects of sugi and hinoki barks on plant growth seem to be polyphenols, condensed tannins etc. These compounds are known to be insolubilized by gelatin etc. which partly alleviate such detrimental effects [1]. Therefore, some chemicals which might react with polyphenols were investigated whether they could suppress the plant growth inhibition or not.

Effects of gelatin and PVP are shown in Fig. 7 and Fig. 8. Blank means the growths of cucumber in the media with cotton and water. Gelatin or PVP were added into the media with methanol extractives (4% to the media) from sugi or hinoki inner barks. Upper and downer directions mean stem and root lengths, respectively. Gelatin and PVP are apparently effective to diminish the growth inhibition and 2% of each chemical is sufficient to control the inhibitory effects of methanol extractives from sugi and hinoki inner barks.

Other chemicals, e.g. urea resin, casein, chitin, chitosan, CaO, polyethyrene imine (PEI), polyacryl amide (PAM), polyethyrene glycol (PEG) etc. were also investigated. Among them, urea resin, PEI and PEG are hopeful for controlling the growth inhibition caused by sugi and hinoki barks.

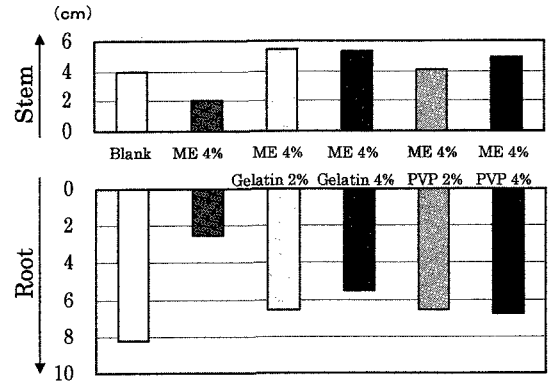

Fig. 7 Control of inhibitory effects of methanol extractives (ME) from sugi inner barks on cucumber growth by addition of gelatin or polyvinyl pyrrolidone (PVP).

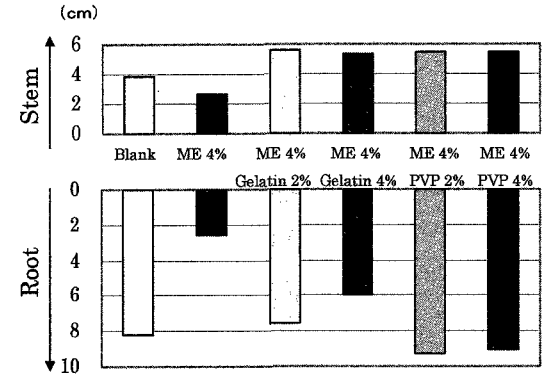

Fig. 8 Control of inhibitory effects of methanol extractives (ME) from hinoki inner barks on cucumber growth by addition of gelatin or polyvinyl pyrrolidone (PVP).

4. CONCLUSION

To utilize sugi and hinoki barks as agricultural materials, not only qualitative but also quantitative difference of their extractives are quite important. Bark extractives, especially phenolic substances are easily changed by seasoning of the barks, therefore chemical aspects, at least polyphenol contents etc. should be clarified when the barks are used practically.

As major inhibitory substances in the barks are polyphenols, like tannins, chemicals to insolubilize the tannins are effective to diminish the inhibitory effects of sugi and hinoki barks on plant growth.

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