Effect of Filtered Torrefied Wood Powder Extract as a Plant Growth Retardant

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The effect of filtered torrefied wood powder as a plant growth retardant was evaluated. The filtered extract was manufactured using torrefied wood powder (*Quercus serrata* Thunb. Ex. Murray) and distilled water. The filtered extracts were used to create four solutions of varying concentration (1%, 5%, 10%, and 20%). Each solution was applied to various seedlings (*Amaranthus retroflexus, Plantago asiatica, Echinochloa crus-galli var.*) over the course of six days. Additionally, gas chromatography-mass spectrometry (GC/MS) was performed to investigate how plant growth was affected. The results indicated that higher concentrations of filtered extract delayed seed growth more than solutions of lower concentration. Additionally, the GC/MS analysis of the filtered extract of torrefied wood revealed one phenolic compound and two different types of furan compounds. This study investigated the active components of torrefied wood as plant growth regulators.

Keywords: Torrefaction; Filtrate; GC/MS; Germination test; Plant growth retardant

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INTRODUCTION

As the standard of living has increased, people have become interested in eco-friendly materials and techniques for environmental conservation. Consequently, the agricultural pesticides industry has declined (Geon *et al*. 2005). An alternative to agricultural pesticides is the use of pyroligneous liquor, which is created through the carbonization of wood rather than of existing chemical composition (Kim *et al*. 2000). The manufacturing process of pyroligneous liquor is similar to that of the condensed steam process of charcoal manufacturing, which contains 80 to 90% water and 10 to 20% organic compounds. These organic compounds consist of 200 different components including organic acids and phenol, carbonyl, and alcohol compounds (Yatagai and Unrinin 1989). Depending on its components, pyroligneous liquor catalyzes or inhibits plant growth, which makes it useful for a variety of purposes (Ahn *et al*. 2003). Therefore, an agricultural chemicals substitute introduction plan using wood carbides, such as pyroligneous liquor, is expected to overcome the environmental pollution caused by agricultural chemicals. However, an economic analysis of this technique is needed before it can be industrialized. Because the wood-carbonization process is too long, normally 3 to 5 days, pyroligneous liquor has a low production rate and it is an expensive product. Therefore, a high production rate and fast wood-carbonization process are needed to economically improve the product.

Due to the high cost of wood carbonization, the torrefaction technique has recently gained attention. Torrefaction is the thermochemical treatment of wooden bio-mass

materials under 200 to 300°C (low temperature carbonization) in non-oxygenated air. This process is similar to the chemical changes that occur during charcoal production (Tooran *et al.* 2014). Therefore, it is necessary to compare the similarities between wood carbonization and torrefaction. In addition, the components of carbonized wood have different quantitative and qualitative properties. The most prominent variance is that hardwood has more thermolysis products (such as methylfurfural, acetosyringon, *etc*.) than softwood (Candelier *et al*. 2011).

For the study, *Quercus serrata* Thunb. ex Murray was used, and a wood roaster was used to implement the torrefaction treatment to reduce manufacturing time. After treatment, the active components, which affected plant growth (positive or negative effect), in each concentration were extracted using hot water, and each concentration solution was filtered. Lastly, the extracted liquids and pyroligneous liquor were examined as plant growth retardants. This study investigates the active components of torrefied wood as plant growth regulators.

EXPERIMENTAL

Materials

Torrefied wood powder

For torrefied wood powder, *Quercus serrata* Thunb. ex Murray chips from Pungrim Corp. (Eum sung, Korea) were used as testing material. The average size of wood chips was about 32.5 mm x 40.0 mm x 3.9 mm, and the wood chips were dried using a force blower dryer at 105 ± 30 °C for 48 h. Torrefied wood powder was manufactured using the wood roaster shown in Fig. 1. This wood-roasting method's optimum condition has been evaluated before (Lee and Kang 2014, 2015), and the present study was performed using the reference conditions. The inside of the roaster was free of oxygen, and any gases were filled inside. Only LPG was used as a fuel for the burner. For the experiment, 2000 g of dried chips were placed in the machine when the temperature of apparatus' air reached 220 °C, such that the temperature of the surface of the roaster was around 350 to 400 °C. After 180 s, torrefied chips were collected and milled into 20-mesh powder.

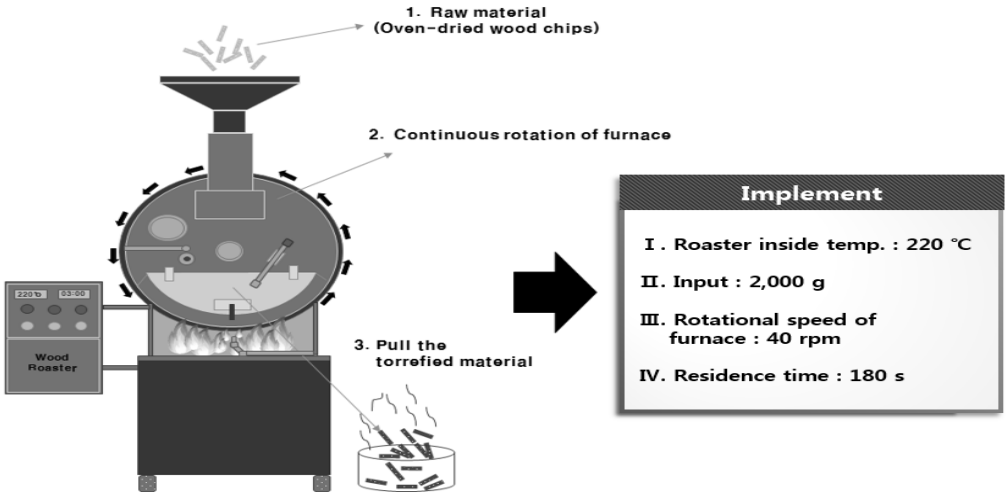

Fig. 1. Process of torrefaction wood powder manufacturing

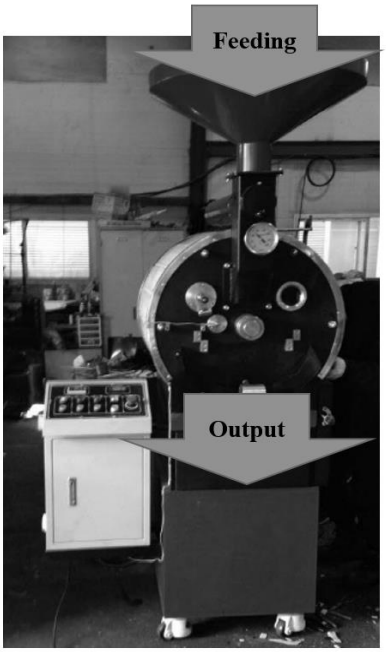

Fig. 2. Image of wood roaster

Process of filtered extract

Whole ground torrefied wood powder was used for hot water extraction, and the powder was mixed with distilled water to concentrations of 1%, 5%, 10%, and 20%. All mixtures underwent hot water extraction to increase the ratio of active components. Hot water extraction was performed at three different times (1, 5, and 10 h). Following the extraction, all mixtures underwent a filtered extraction process using an aspirator. The final product was used as testing material.

Methods

Gas chromatography/mass spectrometry

GC/MS analyses were performed using a Thermo Fisher HP 5890 Series II GC gas chromatograph (Wilmington, DE, USA) equipped with a split/splitless injection port. The substances were separated on a VF-5MS capillary column (equivalent to 5% phenyl, 95% dimethylpolysiloxane, 30 m × 0.25 mm, 0.25 μm film thickness). A constant flow of helium (1 mL/min) was used as the carrier gas. A quantitative test was performed using an HP 5971 MSD (mass elective detector; Wilmington, DE, USA) at a 28 to 550 mass range with a speed of 1.0 s/decade and an ionizing voltage of 70 eV. Data processing was performed on an HP Chemstation data system.

The injector initial temperature was 260 °C, and chromatograms were obtained in splitless mode. The column temperature was held at 45 °C for 1 min and was increased to 100 °C at the rate of 10 °C/min, to 250 °C at 7.5 °C/min, to 300 °C at 10 °C/min, and then held for 6 min.

Plant germination experiment

For the plant germination portion of the experiment, *Echinochloa crus-galli var.*, *Amaranthus retroflexus*, and *Plantago asiatica* (which are considered weeds) were used as the experimental seeds. These seeds were spread on 90-mm Petri dishes lined with filter paper. Ninety milliliters of the filtered extraction (classified concentration, hot water

extraction conditions) solutions were sprayed on the Petri dishes. The experiment was performed at room temperature over a 6-day period (24 °C, 55%). The percentage of germinated seeds was calculated daily.

RESULTS AND DISCUSSION

Component Analysis

Table 1 shows the mixtures detected by the GC/MS test. Torrefied wood powder had 2,5-furandicarboxaldehyde (furan) and 4-hydroxy-3-methoxy-benzaldehyde (phenolic) mixtures, but the control, non-torrefied wood powder, did not. Some new mixtures were detected during the torrefaction treatment. Similar results were found by Toorans *et al.* (2014). Torrefied wood powder contains two furan and three phenolic mixtures. Furan mixtures originate from cellulose, and phenolic mixtures originate from lignin (Zheng *et al.* 2012). Additionally, the detected components have antibacterial, disinfection, deinsectization, and antioxidation functions (Hamed *et al.* 2012; Kim *et al.* 2014; Zekeya *et al.* 2014). This is especially true for 5-methyl-2-furancarboxaldehyde, which is the most antibacterial component (Zekeya *et al.* 2014). Only three furan mixtures were detected in 20% of the torrefied wood powder that underwent 10 h of hot water extraction without phenolic mixtures (4-hydroxy-3-methoxy-benzaldehyde and 2,6-dimethoxyphenol). Consequentially, the hot water and filtered extractions of torrefied wood powder had certain amounts of active components that act as plant growth regulators.

Table 1. Compound Contents in Specimens Obtained from GC/MS (Unit: ug/g)

Compound	Untreated Wood powder	Torrefied Wood powder	Filtrate (20%, 10 h)
5-Methyl-2-furancarboxaldehyde	0.036	0.041	0.791
2,5-Furandicarboxaldehyde	-	0.121	0.447
4-Ethyl-1,3-benzenediol	0.044	0.052	0.578
4-Hydroxy-3-methoxy-benzaldehyde	-	0.046	-
2,6-Dimethoxyphenol	0.063	0.429	-

Plant Germination Experiment

Tables 2, 3, and 4 show the percentages of plant germination after the seeds were sprayed with the filtered extractions. Generally, seeds sprayed with a higher concentration had a lower germination rate. Additionally, a longer hot water extraction period resulted in a low germination rate. This is consistent with the longer period of hot water extraction yielding more active ingredients than lower. Consequently, hot water extraction time and concentration were inversely proportional to the plant germination rate. Furthermore, *Echinochloa crus-galli* var. exhibited the same final germination rate. Therefore, it is believed that filtered extraction is capable of controlling plant germination, but it depends on the species of plant. However, all of the test species had low germination rates when treated with a higher concentration solution. As a result, because detected mixtures on GC/MS are able to inhibit plant growth, it is possible to use torrefied wood powder as plant growth regulator.

Table 2. Result of the Germination Test of *Amaranthus retroflexus*

Amaranthus retroflexus Plant germination percentile: %													
Day	Con.	1%			5%			10%			20%		
		1h	5h	10h	1h	5h	10h	1h	5h	10h	1h	5h	10h
4	40	20	5	-	5	-	-	-	-	-	-	-	-
5	70	40	10	5	15	-	-	-	-	-	-	-	-
6	90	55	35	5	15	-	-	-	-	-	-	-	-

Table 3. Result of the Germination Test of *Plantago asiatica*

Plantago asiatica Plant germination percentile: %													
Day	Con.	1%			5%			10%			20%		
		1h	5h	10h	1h	5h	10h	1h	5h	10h	1h	5h	10h
5	45	25	55	40	35	-	-	-	-	-	-	-	-
6	80	80	75	85	90	100	95	35	25	15	-	-	-

Table 4. Result of the Germination Test of *Echinochloa crus-galli var*

Echinochloa crus-galli var. Plant germination percentile: %													
Day	Con.	1%			5%			10%			20%		
		1h	5h	10h	1h	5h	10h	1h	5h	10h	1h	5h	10h
2	50	35	45	60	30	35	15	20	-	-	-	-	-
3	95	65	95	100	90	85	60	90	75	35	45	20	15
4	100	85	100	100	95	95	95	100	95	95	90	100	60
5	100	90	100	100	95	100	95	100	95	95	95	100	100

CONCLUSIONS

1. Torrefied wood powder (*Quercus serrata* Thunb. ex Murray) was prepared in a new mixture (2,5-furandicarboxaldehyde and 4-hydroxy-3-benzaldehyde). Torrefied wood powder contained two furan mixtures and three phenolic mixtures.
2. A plant germination experiment, except *Echinochloa crus-galli var.*, using the filtered extraction of torrefied wood powder indicated a higher concentration of extracts, which resulted in a low plant germination ratio because of its components. Therefore, it is assumed that torrefied wood powder extract can be used as a plant growth regulator.

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