Development of a natural plant-nutrient from wasted tea leaves and stems

Kim, Jong Cheol[1], Kim, Rumi, Cho, Kyoung Hwan, Kim Yong Duck, Hwang, Jung Gyu , Han, Jae Yoon, Lee, Jong Gug

Key words : Plant nutrient, Green tea, Polyphenol, Plant biomass

Abstract

Plant biomass is a huge carbon-complex that has potential as a nutrient. Therefore we extracted and separated useful materials for plant growth from tea leaf and stem. The pre-treatment process including high temperature (200 °C) and pressure (20-40 kgf/cm^2) was treated for several minutes and extracted at 120 °C for 30-60 minutes. After that the chemical compositions and ingredients were analyzed from that plant-nutrient. As a result of mineral contents, calcium and magnesium concentrations are higher than other minerals. Also the result of carbohydrates analyses has shown that the sugar oligomer consists of xylose(95.3%) and glucose(4.7%), and the sugar monomer consists in the order of xylose (52.7%) > manose (22.8%) > arabinose (10.8%) > galactose (10.2%) > glucose (3.5%). Before applied to field, in vitro plant growth system and formulation were examined. To evaluate the effect of the nutrients, both strawberry green-house and persimmon fields were used in this test. The treated persimmons were heavier than controls scored at 13-22%. In addition, the storage-period was extended in the treated strawberries. Interestingly in the treated strawberry, the contents of polyphenols were increased (38-57%). These results suggest that the plant-nutrient can afford to help for plant growth and storage, and it can be substituted for other commercial nutrients. In conclusion, this plant-nutrient may help to extend eco-friendly or organic farming in Hadong-gun area.

Introduction

Plants require 13 mineral nutrient elements for growth. The elements that are required or necessary for plants to complete their life cycle are called essential plant nutrients. Each of these nutrients has a critical function in plants and are required in varying amounts in plant tissue. Macronutrients (nitrogen, phosphorus, potassium, calcium, magnesium and sulfur) are plant nutrients required in the largest amount in plants. Micronutrients (iron, copper, manganese, zinc, boron, molybdenum and chlorine) are required in relatively smaller amounts. Additional mineral nutrient elements which are beneficial to plants but not necessarily essential include sodium, cobalt, vanadium, nickel, selenium, aluminum and silicon.

The tea tree leaves and stems contain cellulosic plant material, which is a huge biomass that might use as carbon resources. Also the representative tea polyphenol,

[1] Institute of Hadong Green Tea, 539 Buchun-ri, Hwagae-myon, Hadong-gun, Gyeongnam, 667-822, KOREA, jckim@hgreent.or.kr, www.hgreent.or.kr

catechins have various roles such as anti-cancer, anti-fungal and anti-virual effects(Jeong). Polyphenols have one or more phenol units in their chemical structure and are a group of secondary plant metabolites, which play an important role in the growth, development, and defense system of plants (Sellappan & Akoh). Moreover, increased polyphenols in fruits and edible plants give positive health effects to human. The content of nutrients and secondary plant metabolites in food products is affected by growth conditions, use of fertilizers, climate, biotic and abiotic stresses and plant nutrient availability (Fritz *et al*)

In this study, we investigated the availability of a plant-nutrient (called Damoa) made from tea tree leaf and stem. To do this, the tea leaf and stem was degraded and hydrolyzed by high press and temperature, and changed to low molecules such as oligomers and monomers. The final product was used to analyzed and tested for field trials. The Damoa treated fruits were evaluated by growth size, storage period and polyphenol contents.

Materials and Method

Plant materials : The wasted and abandoned tea tree (*C. sinencis*) leaves and stems were used to develop green tea plant-nutrient. For field trials, the plant-nutrient was applied to strawberry *(F. × ananassa)* green house and persimmon (*Diospyros kaki*) field.

Development of green tea plant-nutrient : The lignocellulosic biomass (tea tree) was steam exploded by high pressure, 20~40 kgf/cm2 and high temperature, 200℃ under saturated moisture (Mosier *et al*). The pretreated materials were diluted to water (9:1), and then extracted for 30-60 minutes at 120℃. Finally, the extracted tea materials were separated by filtration.

Analysis of polyphenol contents : Polyphenol contents were analyzed by Folin-Denis method (AOAC) with minor changes. The polyphenol contents were measured with spectrophotometer at 765nm.

Application of plant-nutrient to strawberry and persimmon fields : For field trials, one persimmon field and one strawberry green-house were selected and treated with plant-nutrient to the plant in first year. In 2nd year, 10 strawberry green-houses were treated and evaluated storage period and polyphenol contents with strawberry samples.

Results and Discussions

Development of plant-nutrient from tea tree leaves and stems : To renewal abandoned and wasted tea leaves and stems, we extracted and separated useful materials for plant growth from tea leaves and stems. The pre-treatment process including high temperature (200 °C) and pressure (20-40 kgf/cm^2) was performed for several minutes and then extracted at 120 °C for 30-60 minutes. Next the reaction residues were dehydrated and mixed with the extracted solution, and finally a filtration process was performed. The raw product was used as original nutrient solution, and in this solution, some inorganic elements were added in this original solution.

Analysis of the compositions of plant-nutrient : The inorganic and organic compositions of raw product green tea (GT) extract and added inorganic element nutrients were analyzed. The inorganic and organic contents of raw product were analyzed 14.6% and 85.4%, respectively (data not shown). Moreover, we analyzed total polyphenol contents from both samples. The original extract (raw product) value was 57.6 mg/g, on the other hand the modified (added inorganic elements) nutrient had 30.3 mg/g content. This result suggests that polyphenols of the GT plant-nutrient may affect plant growth system and defense mechanism

Germination and growth test of plant-nutrient : To test the effect of steam exploded green tea (GT) extract on plant germination and growth, the red lettuces seed were socked in the diluted raw product. As shown in Fig. 1, after 3 days later, all seeds were germinated including control. The relative germination ratio indicated that the even high concentration (250X) of GT extract was no harmful during germination (Fig. 1b). Then the plant growth was examined on soil-pot for 15 days with spraying diluted GT extracts. The result has shown that the GT extracts help to plant growth especially stem and root growth (Fig. 1c). These results suggest that this GT plant-nutrient is useful to germination and growth of plants.

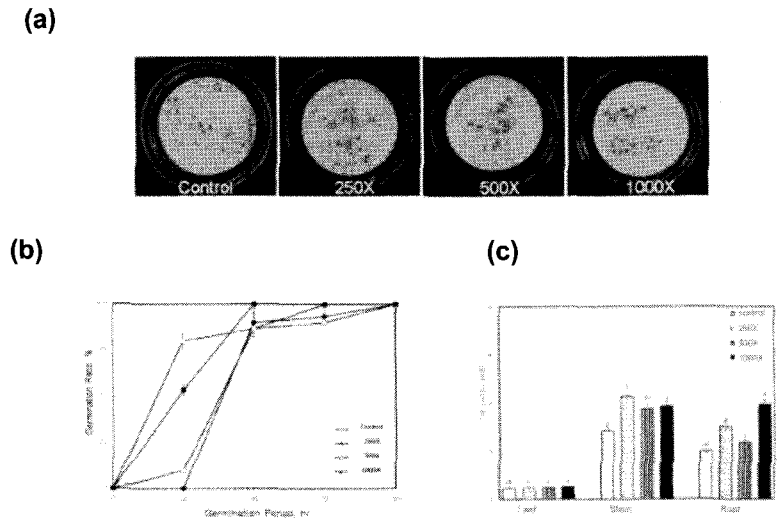

Fig. 1. Germination(3 days) and growth(15 days) test of red lettuce treating with diluted GT plant-nutrient

Field trials for plant-nutrient (Damoa) and evaluation of Damoa treated fruits : To exam the effect of plant-nutrient, persimmon trees and strawberry plants were used in this experiment. The plant-nutrient was treated more than 7 times with minor changes focusing on fruits size and weight and storage period, persimmon and strawberry respectively. As shown in Fig. 2, the persimmons weights were increased 13% ~ 22%

range in all tested groups compared to the control. On the strawberry fruits, the storage period extension was tested in room temperature condition. After 7 days later, the B group (50% GT extract content) sample was significantly extended storage time. In addition we examined polyphenol content in the fruits, which is a group of secondary plant metabolites. The results have shown that in the B and C (50% GT extract content) group, the polyphenol contents were higher than the control, over 57% and 38% respectively. This result suggest that the increased polyphenols may confer positive health effects and affect to plant growth, development, and defense system of plants.

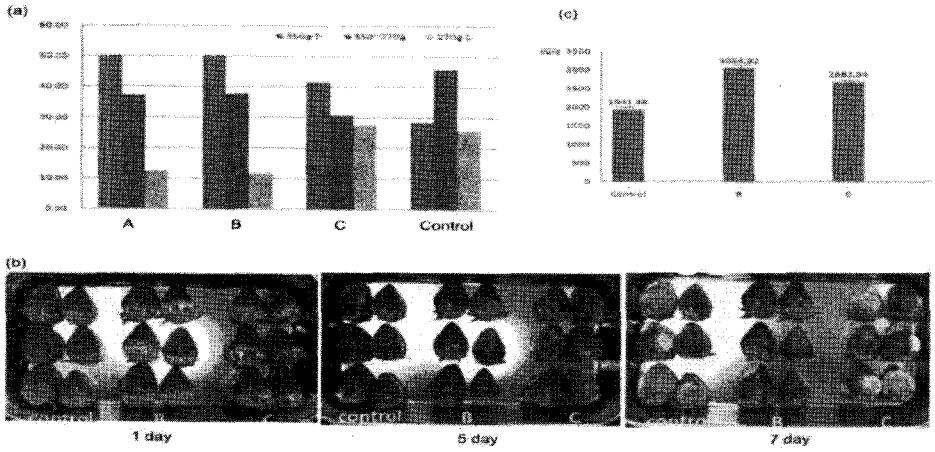

Fig. 2. (a) The increment of persimmon fruits growth that treated with GT nutrients. (b) Storage-period extension test of strawberry at RT for indicated days. (c) Polyphenol contents of harvested strawberry fruits. A: a nutrient that contains 25% of GT extract; B: a nutrient that contains 50% of GT extract; C: a nutrient that contains 75% of GT extract

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