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PROMOTION OF EXTRACTION OF GREEN TEA CATECHINS IN WATER EXTRACTION AT LOW TEMPERATURE USING ULTRASOUND

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Abstract

Attention has been paid to the pharmacological actions of natural elements since hazardous properties of artificial synthetic things contained in foods and medicines have come to be indicated.
Lots of catechins, polyphenols, are contained in green tea. It is known that the catechins have many actions such as antioxidation and antibacteria. Effective use of catechins in green tea is expected. For extracting the green tea catechins, the hot water extraction method and the organic solvents method are used. Although the hot water extraction is safe, the heat causes changes in quality and loss of catechins. Extraction at low temperatures is desirable to avoid these changes, while efficiency of the extraction is low. Authors have made studies to raise the efficiency by using ultrasound and have found that ultrasonic irradiation is effective.
In this study, the effect of ultrasonic frequency on the promotion of extraction was mainly examined. Ultrasonic frequencies used were 25, 45, 100 and 130 kHz. Catechins extracted versus irradiation time were measured. It was found that the extraction was promoted by ultrasonic irradiation in all frequencies. The degree of promotion increased with frequency in the examined frequencies.

1. INTRODUCTION

Tea is the most consumed beverage in the world aside from water. Three billion kilograms of tea are produced each year worldwide. Because of the high rates of tea consumption in the global population, even small effects in humans could have large implications for public health. Among teas, green tea polyphenols have been extensively studied as cardiovascular disease and cancer chemopreventive agents. It was clarified that green tea consumption was associated with reduced mortality due to all causes and due to cardiovascular disease. [1]
Lots of catechins, polyphenols, are contained in the tea. It is known that the catechins have many actions such as antioxidation and the antibacteria. The effective use of catechins in green tea is expected. For extracting the green tea catechins, the hot water extraction method and the

organic solvents method are used. Although extraction using the hot water is safe, the heat applied deteriorates green tea quality and catechins are lost. Extraction at low temperatures is desirable; however the efficiency of extraction is low. [2]
We have made studies to raise the extraction efficiency of the catechins by using ultrasound and have found that ultrasonic irradiation is effective. In addition catechins extracted are proportional to the ultrasonic pressure. [3]
In this study, the effect of ultrasonic frequency on the promotion of extraction was examined. The ultrasonic frequencies examined were 25, 45, 100 and 130 kHz.

2. EXPERIMENTAL

2.1 Experimental setup

Figure 1 shows the experimental setup for ultrasonic extraction. A wide-mouthed Teflon (PFA) bottle with 20 mm in diameter, 94 mm in height and 0.3 mm in thickness is used as specimen vessel. Teflon does not chemically affect the specimen and the attenuation of ultrasound is low. The vessel is placed in a stainless steel water tank 230 mm in length, 173 mm in width, and 73mm in depth. Water tanks to the bottoms of which from six to eight 30 mm diameter BLT ultrasonic transducers of respective resonance frequencies bonded were made and used. The frequencies are 25, 45, 100 and 130 kHz. The Teflon vessel with 80 ml of degassed pure water and 80 mg of green tea is placed at 13 mm from the bottom of the water tank. Accordingly, ultrasound is irradiated from the bottom of the vessel in the water tank. The depth of specimen in the vessel is 50 mm. By adjusting the electric power of the oscillator fed to the ultrasonic transducers, ultrasonic pressure is controlled. The distributions of ultrasonic pressure in the Teflon vessel with green tea are measured beforehand using sonic meter SM1000 (Shinka Industry Co.). An irradiation experiment is carried out with ultrasonic frequency as a parameter. Water in the water tank is circulated at a constant temperature with a circulation regulator unit to avoid the effect of ambient temperature and the water temperature rise by ultrasonic irradiation. For comparison, non irradiated green tea as the control is placed in a similar Teflon vessel that is placed in the same circulatory system as that used in ultrasonic irradiation, in order to remove the difference in temperature between irradiation and non irradiation.

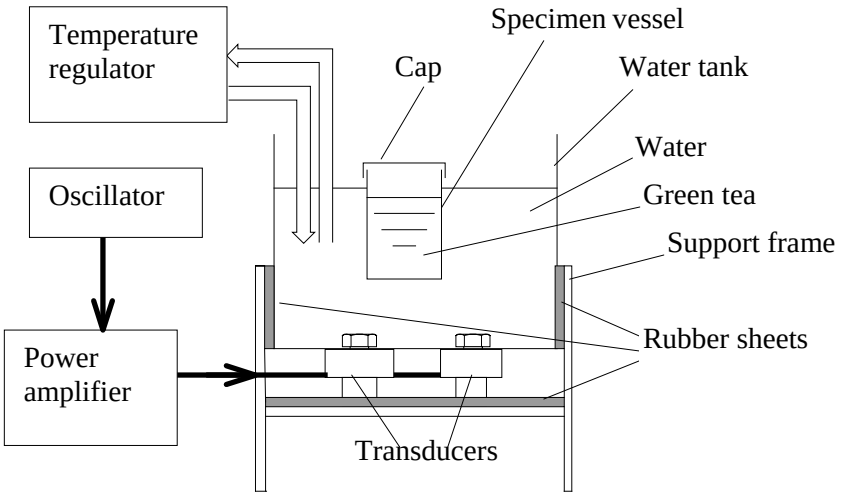

Figure 1. Experimental setup.

2.2 Determination of green tea catechins

After ultrasound irradiation, the catechins extracted from green tea were measured after removing the residue with a filter. In this study, amount of catechins extracted from green tea were analyzed quantitatively using the colorimetric method with ferrous tartrate. By this method, we determined the amount of catechins extracted as follows. [4]

(1) After extraction, filter with dry paper.
(2) Develop the color with the ferrous tartrate solution.
(3) Determine the absorbance of the solution with catechins by comparing with the absorbance of ethyl gallate solution.
(4) Read the ethyl gallate content from the calibration curve of absorbance.
(5) Calculate the amount of catechins from the amount of ethyl gallate.

2.3 Ultrasonic field in the specimen vessels

Figure 2 shows the measured ultrasonic pressure distributions. These are measured in the horizontal plane at tealeaves exist in the specimen vessel. (a), (b), (c) and (b) are distributions in frequencies of 25 kHz, 45 kHz, 100 kHz and 130 kHz. In all frequencies, as shown, pressure deviation is within ±3 dB and average value of pressure over whole plane is 10 kPa.

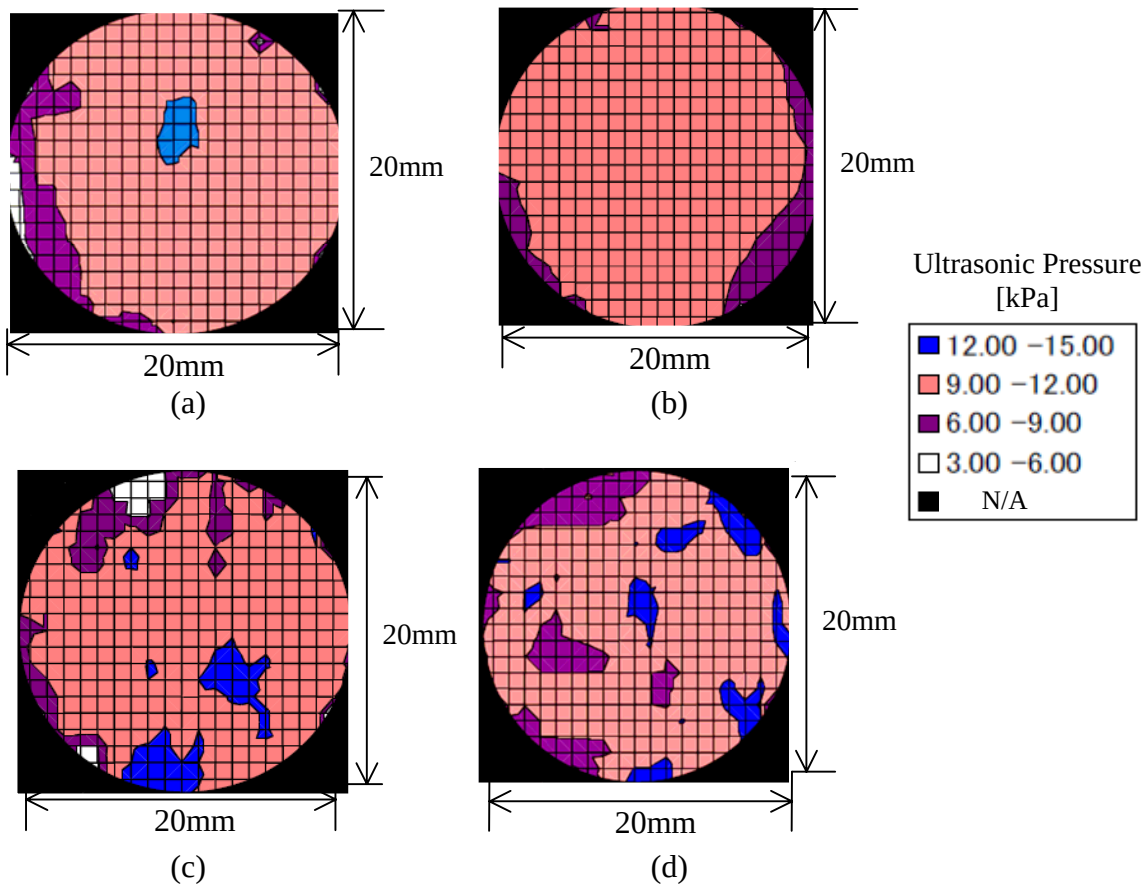

Figure 2. Ultrasonic field in the vessel, (a) 25 kHz, (b) 45 kHz, (c) 100kHz, (d) 130kHz.

3. RESULTS

Figure 3 shows the measurement results of catechins extracted from green tea versus time with ultrasonic irradiation and non irradiation. Frequencies of ultrasound irradiated are (a) 25 kHz, (b) 45 kHz, (c) 100 kHz and (d) 130 kHz. Ultrasonic pressures in the vessels in these results are those shown in Fig. 2. Temperatures of the water and specimens are the same 25 ℃ which is low compared to those of general water extractions. Tealeaves used in this study were obtained from commercial sources. The amount of the catechins extracted with ultrasonic irradiation was larger than catechins extracted without irradiation.

Figure 4 shows the increase of in the amount of catechins extracted using ultrasound expressed as the ratio R calculated from the date shown in Fig. 3. R [%] is calculated using following equation.

$$R = \frac{A - B}{B} \times 100 \ [\%] \qquad (1)\ ,$$

where A [mg] is the amount of catechins extracted with ultrasonic irradiation and B [mg] is the amount of catechins extracted without irradiation. R, effect of irradiation given to catechins extracted, is relatively large after ultrasonic irradiation begins. With keeping the irradiation, increase of R continues gradually.

Figure 5 shows ratio of the increase of catechins extracted at 60 min in Fig. 4 depicted with frequencies as parameter. It is obvious that efficiency of extraction increases with frequency.

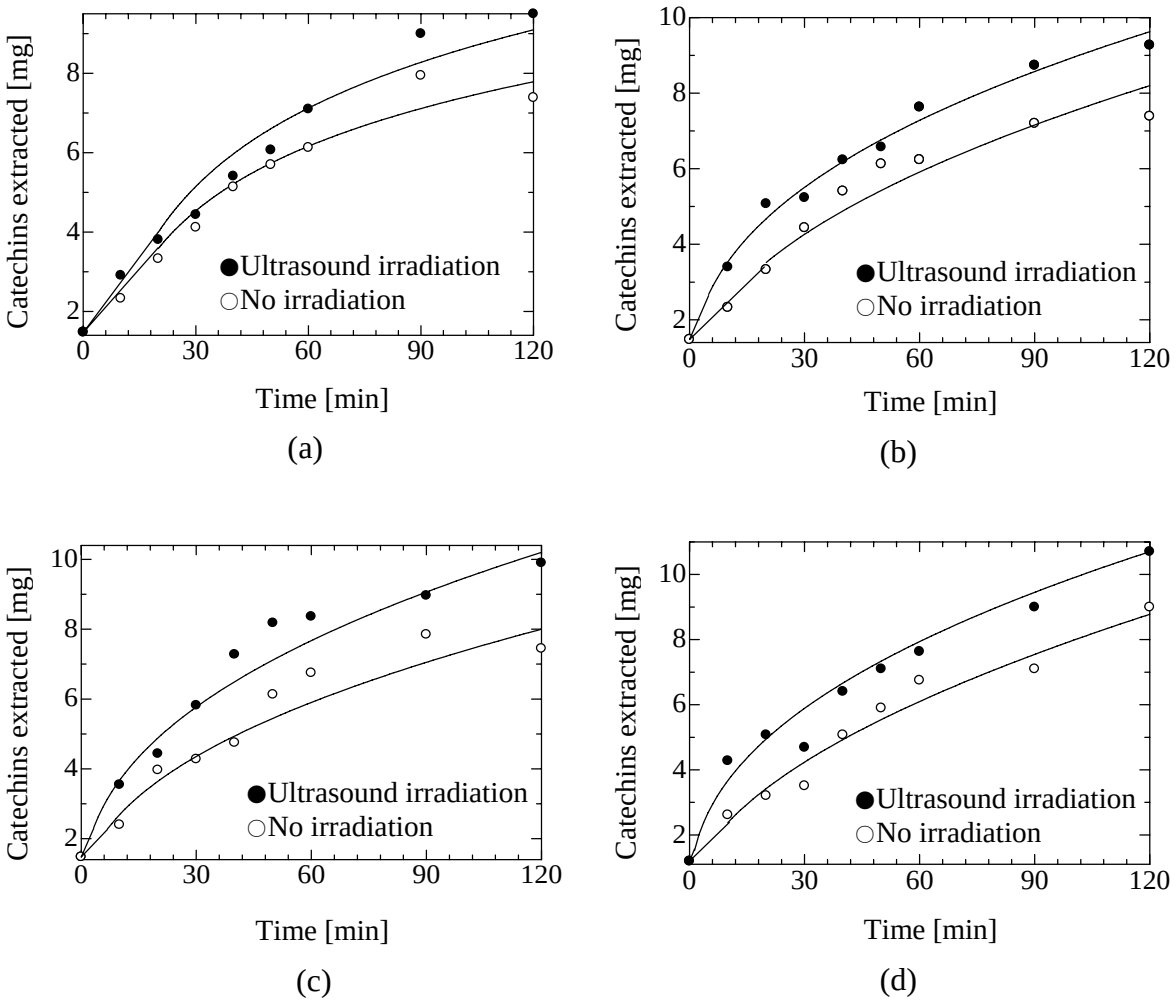

Figure 3. Catechins extracted versus time, (a) 25 kHz, (b) 45 kHz, (c) 100 kHz, (d) 130kHz.

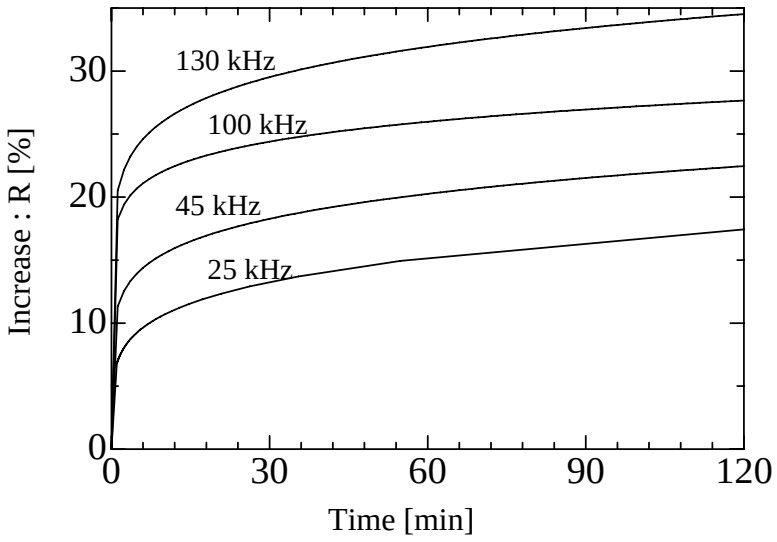

Figure 4. Ratio of catechins extracted between ultrasound irradiation and no irradiation versus irradiation time.

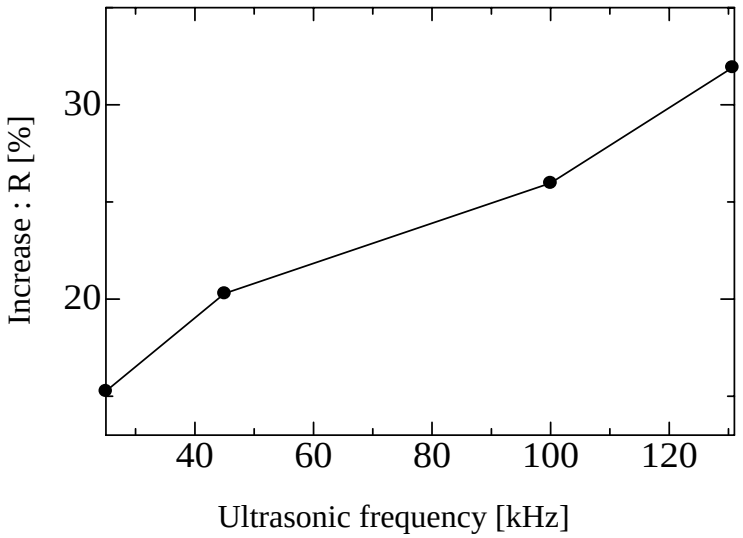

Figure 5. Increase of catechins extracted versus ultrasonic frequency after 60 min ultrasound irradiation.

4. CONCLUSIONS

Study was made to raise extraction efficiency of water extraction of green tea catechins at low temperatures using ultrasound. Effects of ultrasound frequencies irradiated were mainly examined. As a result, it was found that both amount of catechins extracted and efficiency of extraction increase with frequency in the frequency range of this study. Further experiments will be made in order to find optimum frequency together with optimum pressure level for the development of the water extraction for green tea catechins at low temperatures.

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