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Novel decaffeination of green tea using a special picking method and shortening of the rolling process

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ABSTRACT

We have recently succeeded in manufacturing low-caffeine tea (LCT) by employing a special picking method in the 3rd leaf period and shortening the leaf-rolling process. In the present study, the effect of this special method on the content of other physiologically active substances, such as catechins, theanine, and vitamin C, as well as the mechanism of reduction of caffeine content in the LCT were investigated using capillary electrophoresis. By comparing the various components of tea leaves at different picking periods with or without shortening of the rolling process, it was found that the delayed leaf picking period and shortening of the rolling process used in the manufacture of LCT selectively reduced the caffeine content while retaining catechins, theanine, and vitamin C at a sufficient level. Therefore, our study demonstrated that this modified method may be useful in the manufacture of decaffeinated green tea.

1. Introduction

Green tea is a traditional Japanese herb produced by steaming fresh leaves of *Camellia sinensis* without fermentation, and it contains many physiologically active substances (Moore, Jackson, & Minihane, 2009). The main component catechins, such as epicatechin (EC), epicatechin gallate (ECG), epigallocatechin (EGC), and epigallocatechin gallate (EGCG), exhibit various pharmacological effects, such as antioxidative, antitumour, and antimicrobial activity (Hasegawa et al., 1995; Nishida et al., 1994; Roy, Chakrabarty, Sinha, Bhattacharya, & Siddiqi, 2003). Also, an amino acid unique to tea, theanine, induces a relaxing effect and potentiates the effects of anticancer drugs (Kimura & Murata, 1986; Sadzuka, Sugiyama, Miyagishima, Nozawa, & Hirota, 1996; Sadzuka, Sugiyama, & Sonobe, 2000). Many vitamins including ascorbic acid (vitamin C) are also abundant in green tea, and reportedly exhibit an antioxidative effect (Ojo, Ladeji, & Nadro, 2007). Therefore, green tea, being rich in these active components, has been recognised as a 'functional food' with health promoting properties.

On the other hand, green tea also contains abundant caffeine, which is an alkaloid that can have negative effects on the human body depending on the level of intake. Less than 300 mg intake per day is not harmful for adults, but an intake of more than 500 mg has been shown to cause excessive excitation in the central nervous system and cause arrhythmia and vertigo (Paspa & Vassalle, 1984; Seale, Johnson, Carney, & Rennert, 1984). Moreover, caffeine is slowly metabolized in children and pregnant women, remaining in the body for a prolonged period (Giannelli, Doyle, Roman, Pelerin, & Hermon, 2003; Rasch, 2003). Therefore, close attention should be paid to its intake. Accordingly, the removal or marked reduction of the caffeine content of green tea has been actively attempted by establishing a new technique called 'decaffeination' in the manufacturing process. Methods using organic solvents, supercritical carbon dioxide, and hot water have been reported for the decaffeination of green tea (Lee, Park, Kim, & Kim, 2007; Liang et al., 2007; Park, Im, & Kim, 2008; Park et al., 2007). However, the toxicity of residual organic solvents is of concern, and the use of supercritical carbon dioxide requires expensive equipment, increasing the cost. Moreover, regarding the hot water treatment, adding another step to the manufacturing process inevitably increases the production time and cost, reduces the content of not only caffeine but other active components, and leads to a loss of the characteristic colour and flavour of green tea (Lee et al., 2007;Park et al., 2008). Thus, the development of novel decaffeination methods for green tea is called for.

Tea leaves are picked in four periods throughout the year: from the middle of April to the middle of May, from the middle of June to

Abbreviations: LCT, low-caffeine tea; EC, epicatechin; ECG, epicatechin gallate; EGC, epigallocatechin; EGCG, epigallocatechin gallate; Decaffe, commercially produced decaffeinated tea.

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the middle of July, from the end of July to early August, and from the end of September to early October, called the 1st, 2nd, 3rd, and 4th picked teas, respectively (Fig. 1A). The 1st and 2nd picked teas are generally the most expensive, and the price decreases as the picking period is delayed, due to increased toughness of the leaves and decreased amino acid (taste component) content (Kondo, Nakagami, Wada, Imamura, & Shiwa, 2007). Interestingly however, not only the amino acid content but also the caffeine content is reportedly lower in the 3rd and 4th picked tea leaves. Thus, we hypothesised that low-caffeine tea (LCT) could be manufactured from the 3rd and 4th picked tea leaves without the need for existing decaffeination processes. We have recently succeeded in manufacturing green tea with a high chlorophyll content in order to achieve a deep green colour and low caffeine content by employing a special picking method in the 3rd leaf period and using a processing technique (Arahata, 2007) in which the tips (Fig. 1B-b3_1) of the 3rd leaf buds (Fig. 1B-b3) are cut and the leaves are grown further. In the 4th leaf period, the 4th leaf buds (Fig. 1B-b4) in the upper region are cut and the 3rd leaves in the lower region (Fig. 1B-b3) are finally picked. In addition, a processing method used in the production of powdered green tea is employed, that is, the final leaf-rolling step in the general green tea manufacturing process is omitted (Fig. 2). However, these special picking and processing methods were developed based on the experience of green tea manufacturers, and the mechanism by which caffeine content was reduced by the delay in picking and the shortening of the rolling process has not been clarified. Moreover, the effects of these methods on the content of not only caffeine but also the main physiologically active substances, such as catechins, theanine, and vitamin C, remain to be investigated, and quantification of these components may further clarify the commercial value of this LCT.

In this study, we compared the various components of tea leaves picked at different periods (1st, 3rd, and 4th picked tea leaves) and teas prepared using various manufacturing processes. We used capillary electrophoresis, which is capable of simultaneously analysing catechins, caffeine, theanine, and vitamin C, to investigate the cause of the reduced caffeine content and changes in other active component contents with changes in picking period and processing. In addition, the commercial value of the LCT produced by a special picking and processing method was evaluated by comparing its components with those of commercially produced decaffeinated green tea.

2. Material and methods

2.1. Materials

Green tea leaves were provided by Arahataen Co., Ltd. (Shizuoka, Japan). Commercially produced decaffeinated tea leaves were

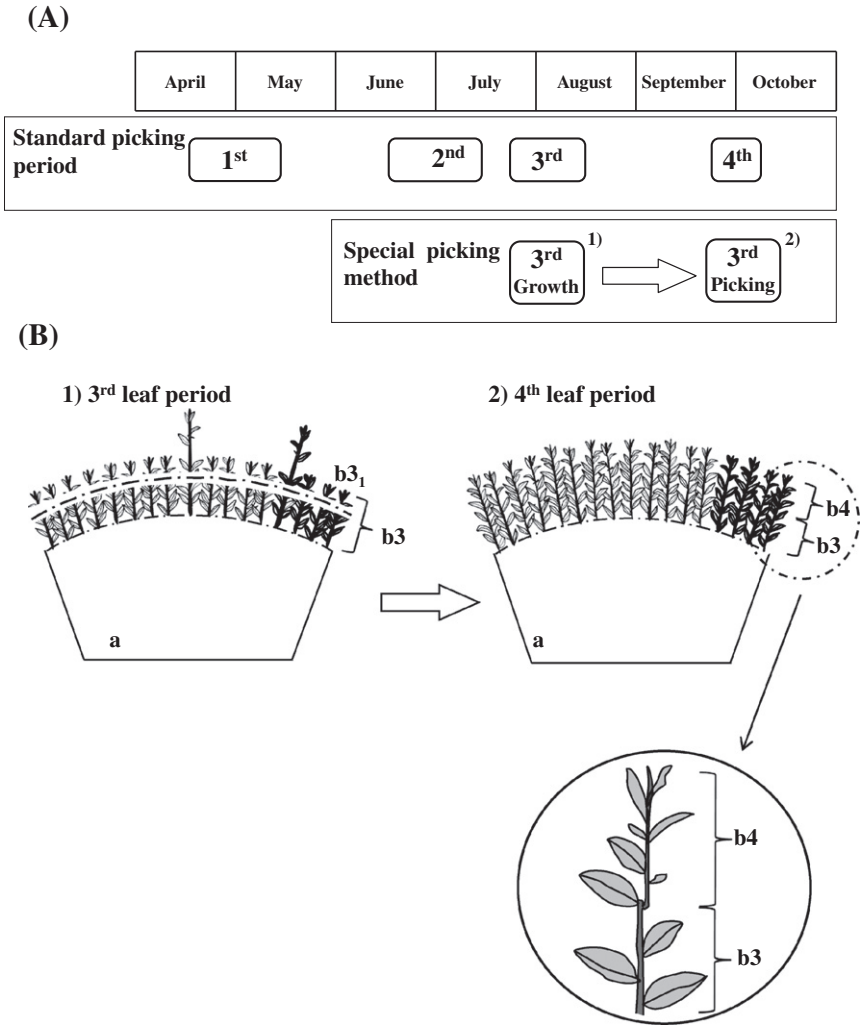

Fig. 1. Normal picking period and special picking method (A) and schematic diagram of the tea plant used for LCT production (B). a: Trunk of tea plant, b3: 3rd leaf buds, b3_1: Tips of 3rd leaf buds, b4: 4th leaf buds.