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Preparation of contemporary dishes and a functional drink using Japan’s heirloom vegetable, Katsura-uri


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A B S T R A C T

Background: The fruit of Katsura-uri, traditionally used in the preparation of pickles in Japan, is facing an extinction crisis. In addition to the traditional dishes prepared from Katsura-uri, alternative dishes using the fruit should be devised to increase consumer demands for the protection of the heirloom vegetable. We attempted designing new Katsura-uri contemporary dishes and assessed the application of Katsura-uri juice as a functional drink without raising blood glucose levels.

Methods: Cooking experiments were conducted with Katsura-uri in its ripening stages, based on the advice from a licensed chef and a registered dietitian in Japan. In the questionnaire-based sensory evaluation, consumer acceptability of Katsura-uri juice was assessed. The blood glucose levels were measured after healthy volunteers consumed the juice.

Results: We demonstrated six new Katsura-uri dishes. In the questionnaire-based sensory evaluation of Katsura-uri juice, the assessment values for taste and fragrance were high. In human trials, the levels of incremental area under the curve and glucose spike were significantly lower after consumption of Katsura-uri juice, as compared to those after consumption of muskmelon juice.

Conclusion: Katsura-uri-containing contemporary dishes and juice would help continue the consumption of the vegetable. Based on the results of the questionnaire, we also concluded that the use of Katsura-uri as a functional drink without raising blood glucose levels is superior to its use as contemporary dishes. These findings provide useful strategies to protect Katsura-uri from extinction.

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1. Introduction

Traditional foods are generally consumed as a part of the culture and history in limited areas of a region. However, consumer demands have shifted from heirloom vegetables to the new varieties of vegetables, resulting in a decrease in the farming area devoted to cultivation of the traditional varieties and, in some cases, termination of commercial cultivation. In the modern world, consumer demands are focused on foods with functional properties, such as possessing low-calorie content, achieving slow increase in blood glucose level, and lowering blood triglyceride level [1,2]. We recently proposed a new strategy to protect Katsura-uri (Japan’s heirloom pickling melon, Cucumis melo var. conomon) (Fig. 1A), using its juice as a functional drink to demonstrate its ability to prevent obesity and diabetes. Katsura-uri was grown and preserved by a single septuagenarian farmer in Japan in 2011 and thus faces an extinction crisis (Fig. 1B) [3].

Traditionally, immature and midripened fruits of Katsura-uri are used in the preparation of pickles, such as kasu-zuke. These are prepared by soaking the fruit for several months in the lees of Japanese liquor and Japanese sweet seasoning liquor [4,5].
However, consumer demands for kasu-zuke have decreased, resulting in a decrease in the number of farmers willing to cultivate Katsura-uri. In addition to the traditional use of Katsura-uri in kasu-zuke preparation, alternative dishes using the fruit during all its ripening stages (immature, midripened, and fully ripened) should also be introduced to increase consumer demands. These dishes would also be valuable for propagating traditional customs by people involved in the Gion-Matsuri festival (one of the three major festivals in Japan and is hosted by Yasaka-jinja shrine every July 1–31 in Kyoto). Since the symbol of the shrine is similar to a sliced section of a cucumber, people involved in the festival traditionally avoid eating cucumber during the festival, which is called kyuridachi, and often eat Katsura-uri instead. However, most people in Kyoto are unaware of this custom and do not follow it. To create awareness about the local food and history of Japanese culture in future generations, formulating recipes that involve the fruit of Katsura-uri would be helpful because, presently, the number of Katsura-uri dishes being offered is limited. Therefore, we designed some contemporary dishes containing Katsura-uri using different cooking styles (e.g., raw, deep-frying, sauté, and boiling) and seasonings, based on the advice of a licensed chef and a registered dietitian in Japan.

To further our knowledge of this heirloom vegetable, we also prepared a novel low-calorie juice from fully ripened Katsura-uri. This beverage would be especially useful and relevant in present times considering the increase in obesity and diabetes cases worldwide. The Katsura-uri juice is a palatable juice possessing low-calorie properties (small amounts of fructose, glucose, and sucrose) and a muskmelon-like fragrance on addition of zero-calorie sweeteners [3]. Thus, Katsura-uri juice has the potential to serve as a functional food for obese individuals and patients with diabetes. Moreover, sensory evaluation by 20 panelists showed high values for taste and muskmelon-like fragrance in Katsura-uri juice sweetened with zero-calorie sweeteners [3]. However, sensory evaluation by large-scale panel was not performed to assess large-scale consumer acceptability. A human trial was also not conducted to assess blood glucose levels after drinking the juice. Therefore, we accomplished sensory evaluation of Katsura-uri juice with the help of 531 consumers and measured the blood glucose levels when healthy volunteers drank the juice in this study.

In this study, we report the preparation of six new Katsura-uri dishes and a Katsura-uri functional drink for the prevention of obesity and diabetes. This could also prove to be a useful strategy to protect Japan’s heirloom vegetable from extinction by increasing its demand as a healthy low-calorie fruit.

2. Materials and methods

2.1. Plant samples

Katsura-uri was harvested in July and August from 2010 to 2014 in an open-field culture system at the Kyoto Prefectural Agricultural Research Institute, Kameoka, Kyoto, Japan. Muskmelon (Cucumis melo var. reticulatus; cultivar name Raiden red) was purchased from a wholesale market in Kyoto, Japan. Immature, midripened, and fully ripened Katsura-uri fruits were stored at 4°C for designing the dishes. Fully ripened Katsura-uri fruits were washed with water and longitudinally cut into four pieces of the same size. Each piece was peeled, and the seeds were removed. The pieces were vacuum-packed in plastic bags and stored at –25°C for the human trials, which involved a taste test and measurement of blood glucose levels. Muskmelon was treated in a similar manner; it was washed with water, cut into eight pieces of the same size, peeled, had its
2.2. Preparation of Katsura-uri dishes

Cooking experiments were conducted using Katsura-uri at all the ripening stages. Six dishes were created based on the advice from a licensed chef (from a Japanese restaurant “Kushikura”) and a registered dietitian in Japan (from a self-company “Concierge of food and agriculture Graine”).

2.3. Preparation of juices

Katsura-uri juice for the sensory evaluation and measurement of blood glucose levels was prepared as follows: 100 g of frozen fruit (stored at −25°C) was thawed partially, chopped, and mixed in an electric automatic mixer (TM840, Tescom Co. Ltd., Tokyo, Japan) with 2.25 g of zero-calorie sweeteners (ingredients: erythritol, aspartame, acesulfame K; product name: Pal Sweet diet) supplied by Ajinomoto Co. Inc. (Tokyo, Japan). Muskmelon juice for measurement of blood glucose levels was prepared as follows: 100 g of frozen fruit (stored at −25°C) was thawed partially, chopped, and mixed in an electric automatic mixer.

2.4. Sensory evaluation of Katsura-uri juice

A total of 531 (199 male, 271 female, 61 unknown) panelists, with ages ranging from 10 to 90 years and from 8 different places, assessed the Katsura-uri juice sweetened with zero-calorie sweeteners. For the determination of consumer acceptability, panelists drank the Katsura-uri juice (50 g) and answered two questions by rating on a 5-point scale. The questions were as follows:

1. “Choose one of the following that applies to the taste of Katsura-uri juice: excellent, good, fair, poor, or very poor”.
2. “Choose one of the following that applies to the muskmelon-like fragrance of Katsura-uri juice: very strong, strong, fair, poor, and very poor”.

2.5. Measurement of the blood glucose level

Ten healthy volunteers (5 men and 5 women, aged 22–25 years) were recruited from Kyoto Prefectural University. Their recruitment was approved by the Ethics Committee of Kyoto Prefectural University. Profiles of human volunteers in height, weight, and body mass index are shown in Table 1. The volunteers were asked to fast but were allowed to consume water, from 22:00 PM on the previous day to the end of the trial. At 10:00 AM on the day of the trial, the peripheral blood glucose level was measured using an automated portable glucose meter (Glutest Sensor and Glutest Every; Sanwa Kagaku Kenkyusho, Nagoya, Japan) from blood samples obtained by a finger-stick sampling. Then, the volunteers drank the Katsura-uri juice (240 g), and the blood glucose levels were measured 15, 30, 45, 60, 90, and 120 min after consumption. Blood glucose levels were plotted, and the incremental area under the curve (AUC) was calculated using the trapezoid rule [6]. On two different days, tests to estimate the blood glucose levels were conducted in participants after they consumed a solution containing 25 g glucose (Trelan-G, Ajinomoto Pharmaceuticals Co. Ltd., Tokyo, Japan) and a solution containing 240 g of muskmelon juice, instead of 240 g of Katsura-uri juice. The muskmelon juice (240 g) contained 25 g of carbohydrates (according to the Standard Tables of Food Composition in Japan 5th revised and enlarged edition; 10.4 g of carbohydrate in 100 g of muskmelon) [7]. Therefore, we used 25 g of glucose solution, equivalent to 25 g of carbohydrates contained in 240 g of muskmelon juice, and 240 g of Katsura-uri juice, equivalent to the total weight of the muskmelon juice (240 g).

2.6. Statistical analyses

Analysis of variance followed by Fisher’s protected least significant difference method were applied for the measurement of blood glucose levels. The results were considered significantly different for p < 0.05.

3. Results

3.1. Preparation of Katsura-uri dishes

One Katsura-uri dish, gomafumi-ae, was prepared as advised by a national registered dietitian in Japan (Fig. 2A). The recipe for the dish is as follows: immature Katsura-uri fruits were washed with water and peeled, and the seeds were removed. The flesh of the fruit cut into 1-cm thick slices, a carrot cut into fine strips, and an eggplant cut into semicircular slices were boiled. Ham and cucumber were cut into fine strips and semicircular slices, respectively. These constituents were dressed with vinegar blended with soy sauce, sugar, sesame oil, and sesame seeds. Five Katsura-uri dishes using different cooking styles and seasonings were prepared based on the advice from a licensed chef. The recipes for the dishes are as follows: Tosa-ae, salt-rubbed midripened Katsura-uri fruit was sprinkled with katsuobushi (dried bonito flakes) on the entire surface (Fig. 2B); agedashi, deep-fried fully ripened Katsura-uri fruit soaked in dashi (fish-broth with soy sauce) (Fig. 2C); ikomi, minced chicken stuffed into hollowed-out fully ripened Katsura-uri fruit (Fig. 2D); kimpira, sautéed finely cut strips of midripened Katsura-uri fruit with soy sauce and sugar (Fig. 2E); kanten-yose, mashed and boiled fully ripened Katsura-uri fruit made into a jelly using dashi and agar (Fig. 2F).

3.2. Sensory evaluation of Katsura-uri juice

Katsura-uri juice was prepared from the fully ripened fruit mixed with zero-calorie sweeteners, and it was evaluated by 531 panelists. In the evaluation of taste of the Katsura-uri juice, the responses of excellent and good were 52.0% and 35.6%, respectively (Fig. 3A). In the evaluation of muskmelon-like fragrance in the juice, the responses of very strong and strong were 37.9% and 52.4%,
The overall result of the sensory evaluation by 531 panelists was high for taste and fragrance.

### 3.3. Measurement of the blood glucose level

Blood glucose levels of 10 healthy volunteers were measured after drinking solutions containing 25 g of glucose, 240 g of Katsura-uri juice, and 240 g of muskmelon juice. All 10 volunteers completed the experiment. The AUC range of 10 volunteers who consumed the solution of 25 g glucose ranged between 32 and 130 h mg/dl. The panels of A to J in Fig. 4 are organized in the order of the AUC levels, A (highest) to J (lowest), per glucose administration. The blood glucose levels of the 10 volunteers were below 100 mg/dl in the three drink trials after fasting, and all the volunteers were healthy (Fig. 4).

The average blood glucose level of the 10 volunteers was plotted (Fig. 5A). Blood glucose levels started increasing immediately after administration of the three drink trials. However, the blood glucose response curve was apparently different among the three trials. The
The level of AUC was found to be 62 ± 9 h mg/dl in the glucose trial (Fig. 5B). However, the AUC levels were 27 ± 3 h mg/dl and 11 ± 2 h mg/dl in the muskmelon and Katsura-uri trials, respectively. The AUC level was significantly lower after consumption of Katsura-uri juice, as compared with that after consumption of muskmelon juice (p < 0.05).

The levels of the glucose spike (the difference between the baseline glucose level and the peak) were also different among the three trials (Fig. 5C). The level was significantly lower after consumption of Katsura-uri juice, as compared to that after consumption of muskmelon juice (p < 0.05).

4. Discussion

For creating awareness in the next generation regarding the local fruit Katsura-uri, which is deeply connected with the Gion-Matsuri festival, we provided six contemporary cooking recipes using the fruit Katsura-uri (Fig. 2). These dishes are useful to people who traditionally eat Katsura-uri during the Gion-Matsuri festival, instead of cucumber. Some dishes have been prepared based on consumer demands at a restaurant, where the licensed chef (provided advice for the preparation of dishes in this study) works in Kyoto city. Currently, very few dishes involve the use of Katsura-uri, and few people know the custom that people involved in the Gion-Matsuri festival avoid eating cucumber during the festival. Therefore, such public campaigns are helpful to generate awareness among the public and also to protect the extinction of Katsura-uri in future.

The total consumption of Katsura-uri through these preparations will still be insufficient as the fruit will only be consumed during the 1-month festival of Gion-Matsuri. Therefore, additional strategies are needed to increase its demand among consumers. Increase in the consumer demand of Katsura-uri will cause farmers to produce Katsura-uri sustainably and protect Katsura-uri from extinction. At present, vegetables that contribute to improving public health are preferably produced in farms in Japan. Although
Heirloom vegetables have not undergone selective breeding, the direction of farming methods is gaining importance. We proposed a new strategy to protect Katsura-uri aimed at using its juice as a functional drink to prevent obesity and diabetes [3]. We surveyed the efficacy of fully ripened Katsura-uri as a low-calorie juice, which would be especially beneficial considering the increase in obesity and diabetes in the modern world. Sensory evaluation of Katsura-uri juice (sweetened with zero-calorie sweeteners) by 20 panelists showed a high satisfaction level in taste and fragrance in our previous study [3]. In this study, we adopted the same procedure of sensory evaluation done with the help of 531 panelists; the number of panelists was increased to validate the results of the previous study. The same high satisfaction level was achieved in our current experiments, irrespective of sex, age, and medical history of diabetes (Fig. 3). In human trials, the Katsura-uri juice can minimize postprandial blood glucose levels and the subsequent glucose spike in healthy humans (Figs. 4 and 5). Thus, we demonstrated Katsura-uri juice as an acceptable and novel functional drink that can be potentially useful for minimizing human postprandial blood glucose levels. The juice can also be considered as a separate dish and different from the repertoire of six dishes of Katsura-uri offered in this study for people participating in the Gion-Matsuri festival.

Low amount of sugars in fully ripened Katsura-uri fruit (2.8 g/100 g) lowered the blood glucose levels in healthy volunteers (Figs. 4 and 5) [3]. Lowering of blood glucose levels has been reported to reduce the risk of type 2 diabetes and cardiovascular diseases among healthy individuals [8,9]. Thus, this juice would be useful for patients suffering from diabetes, a disease that affects about 415 million people worldwide [10]. Therefore, we plan to measure the blood glucose levels in diabetic participants after consistent Katsura-uri fruit juice consumption, which could potentially improve their quality of life in the future. Based on the data of consistent consumption of Katsura-uri, we concluded that the use of Katsura-uri juice as a functional drink, which does not raise blood glucose levels, is superior to its use in the prepared Katsura-uri dishes. These findings might provide a strategic model to protect the crop from extinction in present diet habits.

Conflicts of interest

The authors declare no conflicts of interest.

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