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Possibility of using the tips obtained from the “Uradome” of moso bamboo (*Phyllostachys pubescens*) as a food source

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Abstract

In the cultivation of bamboo shoots in snow-covered areas, uradome is known to prevent snow damage. Although tips can be obtained by uradome, these are currently considered unutilized. Like bamboo shoots, uradome has the potential to be a source of food. Therefore, to explore the possibility of using uradome tips as food, we evaluated their egumi and umami taste, investigated the free amino acid content, and compared these parameters with those of bamboo shoots. The results showed that the egumi taste of uradome tips was weaker than that of bamboo shoots. The umami taste at first taste was weaker than that of bamboo shoots, while the umami and richness that remained after swallowing was stronger than that of bamboo shoots. The presence of a total of 18 free amino acids was evaluated in the uradome tips and bamboo shoots, and 17 free amino acids were detected in the samples, with cystine being the exception. Eleven of these free amino acids were found to be more abundant in the uradome tips. In addition, eight of the nine essential amino acids (excluding tryptophan) were found in the uradome tips and were in approximately the same amounts as in the bamboo shoots. Furthermore, leucine, a commonly known branched-chain amino acid, was present only in the uradome tips. Overall, the results suggest that uradome tips could be used as a food source.

Keywords: Moso bamboo, Uradome tips, Egumi taste, Umami, Free amino acid

Introduction

Moso bamboo (*Phyllostachys pubescens* Mazel ex Houzeau de Lehaie) grows mainly in the tropics and subtropics, but it also grows in some temperate regions [1]. It was introduced to Japan from China approximately 300 years ago [2], and the young shoots are edible, similar to bamboo shoots.

Snow damage, such as culm breakage and collapse, occurs in bamboo forests in snow-covered areas during winter. Snow damage causes a decrease in nutrient assimilation and effects bamboo shoot production in the following year [3, 4]. Previous studies investigated

the effectiveness of uradome in preventing snow damage and the relationship between the optimal timing of uradome and bamboo cell wall components [4, 5]. Uradome is a treatment that involves cutting or breaking off the upper portion of the new culms when the bamboo shoot is almost grown [2–5]. There are two main methods of uradome: one is to use a blade, and the other is to shake them back and forth and breaking the tip using recoil [3, 5]. Of these, since the use of blade can be dangerous, many producers implement the latter, the shake-off method [5]. These studies show that in snow-covered areas, it is necessary to implement the process of uradome at the right time to achieve sustainable bamboo shoot production [4, 5].

Although there is some evidence that the tips removed from uradome culms (uradome tips) are eaten by people in some areas of Yamagata Prefecture, there are no

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clear reports to verify this, and it is assumed that most uradome tips are discarded (Fig. 1). Uradome will be carried out by selecting culms from newly generated bamboo shoots that will become parents and contribute to bamboo shoot production in the following year and beyond. The number of its culms is generally determined by “culm density of bamboo forests divided by the cycle of logging” [3, 6]. Therefore, the amount of tips obtained by uradome depends on the number of culms grown in the current year as determined by each grower and varies according to the management and region. If currently unused uradome tips become more available, it will lead to the promotion of uradome. Therefore, this study focused on the edibility potential of uradome tips. We evaluated the taste of uradome tips by comparing their taste to the taste of bamboo shoots collected in and outside Yamagata Prefecture, as reported by Furusawa et al. [7]. To evaluate the taste of the uradome tips, analysis of egumi taste, as investigated by Furusawa et al. [7], was conducted; umami taste, which is the type of taste often focused on when tasting special forest products such as wild vegetables and mushrooms, was also included. In addition, several amino acids are known to be involved in the taste characteristics of food, such as umami [8]. Furthermore, consumers' needs for food are not limited to satisfying tastes and the intake of nutrients, but they also include the expectation of biological regulatory functions [9]. Therefore, in this study, the content of 18 free amino acids was evaluated from the viewpoint of both taste and functionality; these results were then compared to the corresponding results associated with the bamboo shoots. Based on this analysis, a comprehensive discussion was conducted to examine the possibility of using uradome tips as a potential food source.

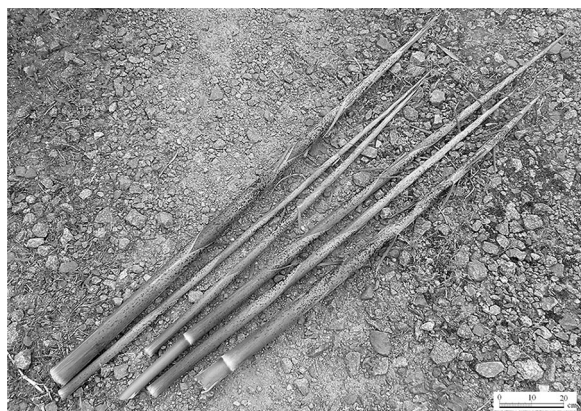


Fig. 1 Bamboo tips generated by uradome. These are the tips that we obtained from uradome. This part falls to the ground via the shake-off method

Materials and methods

Sample collection and preparation

The uradome tips used in this study were collected from a bamboo forest in Yamanobe Town, Yamagata Prefecture, Japan. They were obtained from new bamboo plants that started growing in 2018. Uradome was performed on six culms on June 13, 2018. They were all culms that were deemed suitable time for uradome in the collection area that day. The culms that were conducted were about 1.5 months old after they occurred in early May. The length of the culm at the time was about 8 m, and the sampled tips was about 80 cm. These uradome tips were then collected, peeled, and stored in a freezer until further analysis.

The bamboo shoots used in the comparison test were the same shoots as those described in Furusawa et al.: the bamboo shoots were collected from six locations (Asahi, Haguro, Mikawa, Sanze, Yamanobe, and Yuza) [7]. All the bamboo shoots were frozen and then freeze-dried for about 3 days. Freeze-drying treatment is thought to cause minimal alteration, and thus, the components before drying were almost fully maintained; no change occurred in terms of flavor that would cause the bamboo shoots to lose their original characteristics [10–12].

Taste analysis

Before analysis, six freeze-dried samples of uradome tips were thoroughly mixed to homogeneity. Three bamboo shoot freeze-dried samples from each bamboo forest were also thoroughly mixed and homogenized in the same way for each collection site. After mixing, each sample was weighed (20 g fresh weight equivalent) and soaked for 6 h with distilled water to make a tenfold dilution. The water immersion process was carried out under refrigerated conditions to prevent deterioration due to warmer temperatures. The water and samples were thoroughly agitated with a mixer and then centrifuged at 3000 rpm for 5 min, after which the supernatant was collected. The supernatant solution was frozen and stored until analysis.

Two taste sensors were used for the analyses: α ASTREE (Alpha Moss Japan, Inc., Tokyo, Japan) and TS-5000Z (Intelligent Sensor Technology, Inc., Kanagawa, Japan). The analytical principles and measurement details of these instruments are the same as those described in Furusawa et al. [7].

For the analysis using α ASTREE sensor, egumi taste was subjected to the standard addition method for oxalic acid; moreover, egumi taste is considered to be significantly affected by oxalic acid [7]. Principal component analysis was performed on the uradome tips, three concentrations of aqueous oxalic acid solutions (1 mM,

10 mM, and 100 mM), and bamboo shoots from Yamagata Prefecture. The sensor named NMS, one of the seven sensors on α ASTREE, indicates the direction of umami taste, and the reverse direction indicated by the NMS sensor is representative of a stronger umami taste. For this reason, principal component analysis was performed on the analysis results of uradome tips and bamboo shoots, and the results are discussed in addition to the inverse direction of the NMS sensor. In this study, each sample was measured six times, and the data from the last two measurements, which were considered to be stable, were used. The two measurements were then averaged and used in the principal component analysis. All principal component analyses were performed using Excel statistics version 3.21 (SSRI, Tokyo, Japan).

In the analysis using the TS-5000Z sensor, measurements of bitterness (first taste) and bitter taste (aftertaste), which were shown to be related to egumi taste by Furusawa et al. [7], as well as measurements of umami (first taste) and umami and richness (aftertaste) were included in the analysis. In this study, as in the previous report by Furusawa et al. [7], bamboo shoots from Yuza Town, Yamagata Prefecture, were used as the zero standard, and the four taste parameters of the uradome tips were measured.

Free amino acid analysis

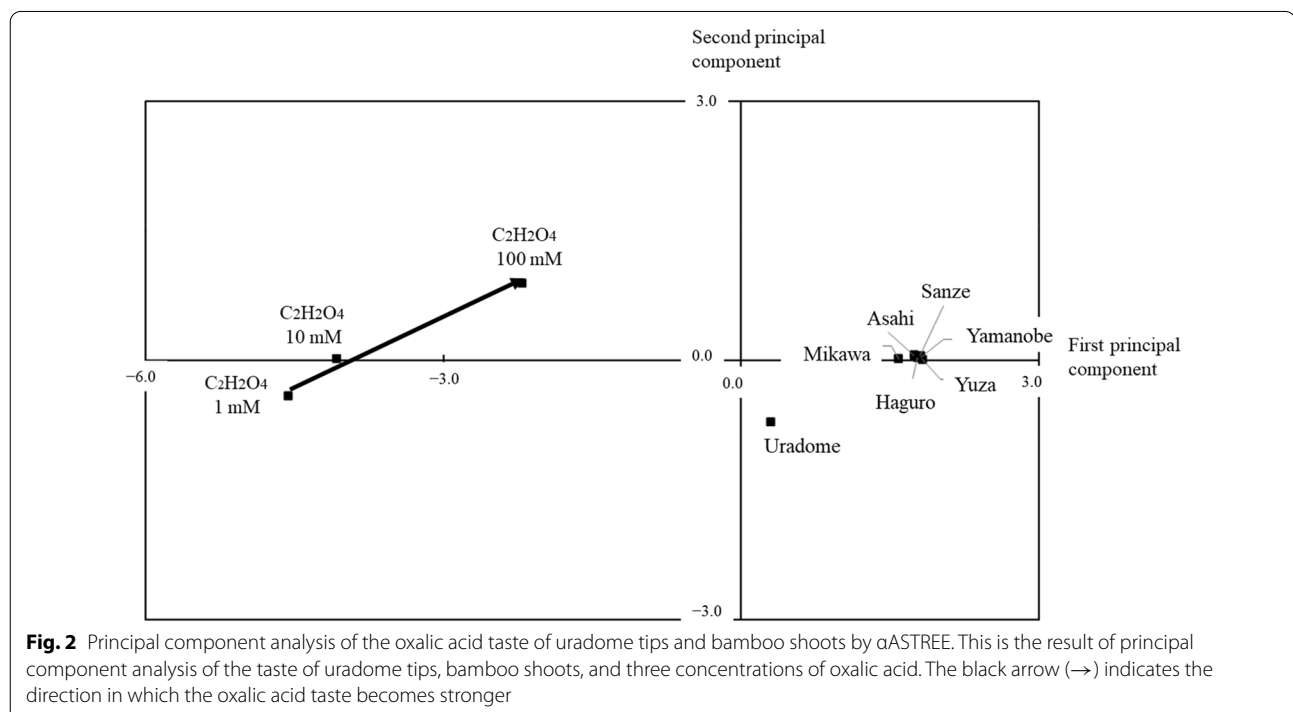
Uradome tips and bamboo shoots collected from the same bamboo forest in Yamanobe Town (comparison

samples) were analyzed for content of 18 free amino acids. The samples used for the analysis were completely mixed to homogeneity with the respective freeze-dried samples, as in the taste analysis. The analysis was commissioned to the Japan Food Research Laboratories (Tokyo, Japan), and was performed using an automated amino acid analysis method or a high-performance liquid chromatograph specialized for the analysis of amino acids.

Results and discussion

Taste analysis

The results of the principal component analysis for uradome tips, bamboo shoots collected from six locations in Yamagata Prefecture, and three concentrations of oxalic acid solution are shown in Fig. 2. The contribution rate of the first principal component was 96.79% and that of the second principal component was 2.34%, explaining approximately 99% of the data. The taste of the uradome tips was plotted in the direction where the first and second principal components were smaller than the sample of six bamboo shoot samples (Fig. 2). The taste of the three concentrations of oxalic acid solution became more positive in the direction of the first and second principal components as the concentration of the oxalic acid solution increased (Fig. 2). These results indicate that the uradome tips had a weaker oxalic acid taste than the six bamboo shoots from Yamagata Prefecture (Fig. 2).



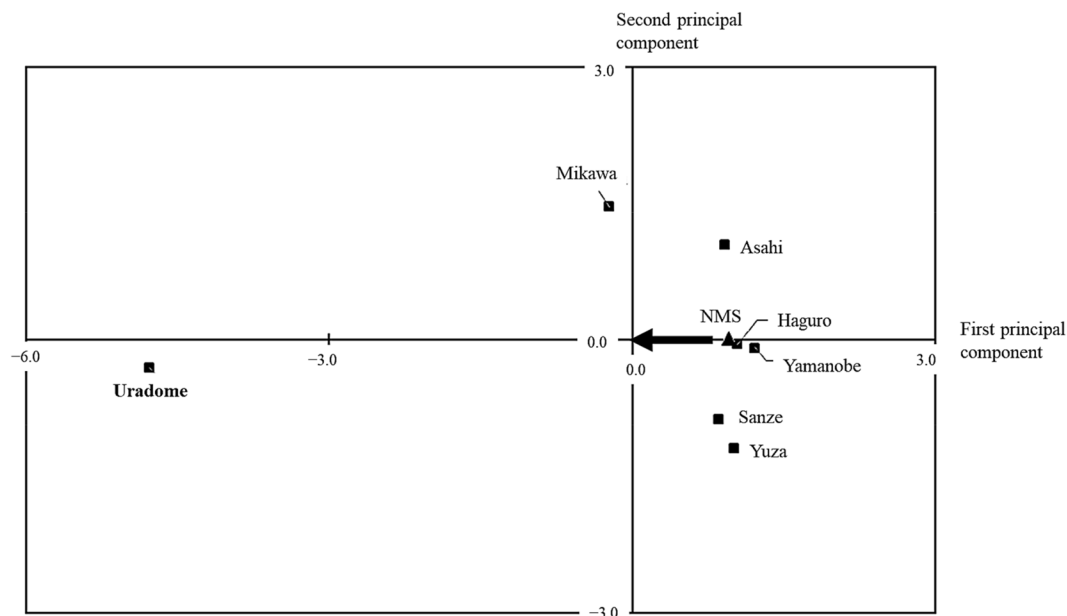


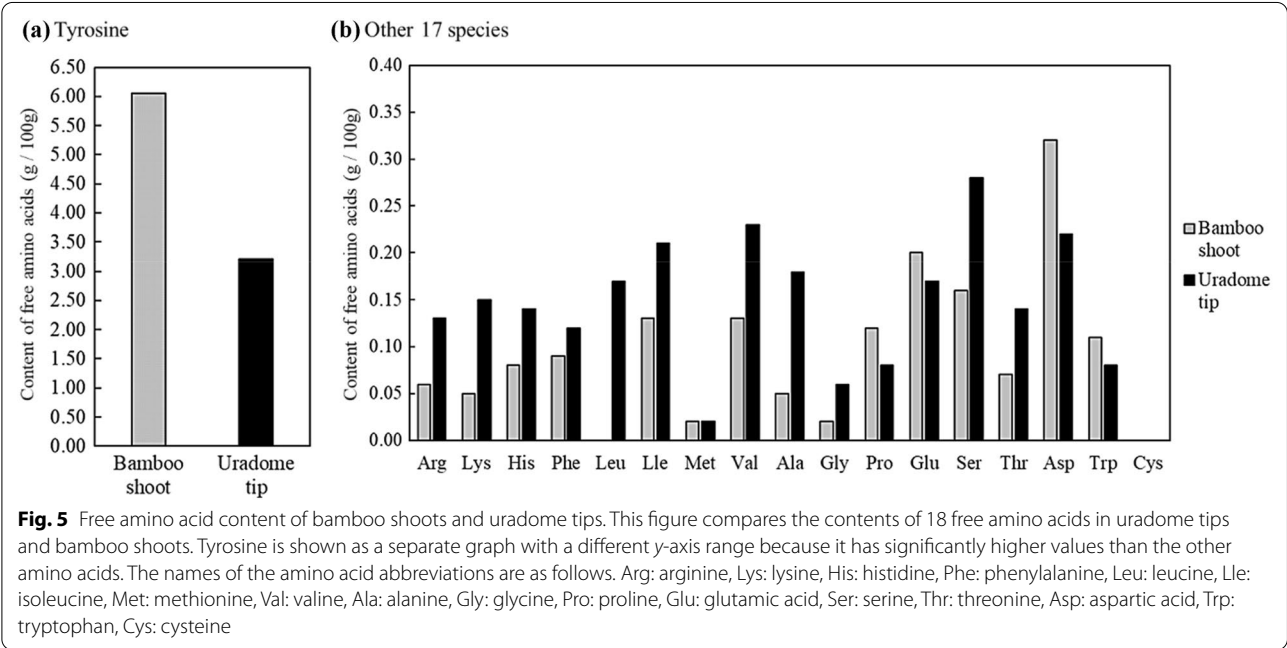
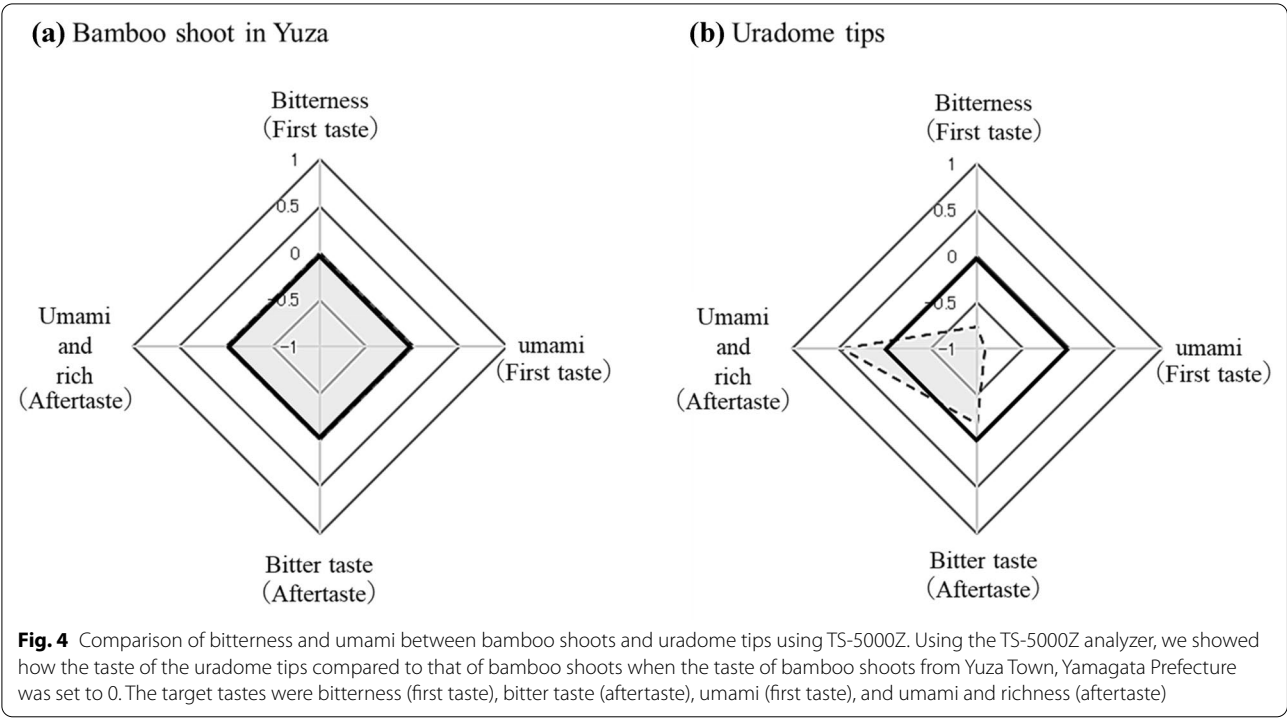
Fig. 3 Principal component analysis of umami of uradome tips and bamboo shoots by α ASTREE. The results of the taste analysis of uradome tips and bamboo shoots were analyzed by principal component analysis, and the sensor directions of umami were added. \blacktriangle indicates the position of the umami sensor NMS; the more the sensor is plotted in the opposite direction (\rightarrow direction), the stronger the umami

Next, the results of the α ASTREE analysis plus the sensor output direction of umami are shown in Fig. 3. The cumulative contribution of the first and second principal components was 93.11%, and more than 90% was explained by the first and second principal component. Umami is stronger in the opposite direction of the NMS sensor output; therefore, the stronger the direction in which the first principal component decreases, the stronger the umami taste (Fig. 3). Uradome tips is plotted in the opposite direction of the NMS output, indicating that it has a stronger umami taste than bamboo shoots (Fig. 3).

Figure 4 shows the results of measurement of bitterness (first taste), bitter taste (aftertaste), umami (first taste), and umami and richness (aftertaste) of the uradome tips based on the bamboo shoots from Yuza Town, Yamagata Prefecture, using the TS-5000Z sensor. The uradome tips had a bitterness (first taste) value of -0.76 , and a bitter taste (aftertaste) value of -0.19 . Both the first taste and aftertaste had smaller values and were, therefore, less bitter than bamboo shoots (Fig. 4). The umami (first taste) value was -0.91 , and the umami and richness (aftertaste) value was 0.46 , indicating that the umami taste first perceived in the mouth was weaker than that of the bamboo shoots, but that a persistent umami taste remained after swallowing and was stronger than that of the bamboo shoots (Fig. 4).

The results of the two taste sensor analyses showed a similar trend. α ASTREE analysis showed that the oxalic acid (related to egumi taste) of uradome tips was weaker than that of the Yamagata bamboo shoots, and TS-5000Z analysis showed that uradome tips were less bitter than the bamboo shoots in both the first and second tastes. Overall, this suggests that the egumi taste of the uradome tips was weaker than that of the bamboo shoots. As mentioned by Furusawa et al. [7], bamboo shoot growers are particularly interested in the degree of egumi taste. A weaker egumi taste in the uradome tips, as demonstrated in this study, would be a great advantage in considering their edibility.

In addition, analysis using the α ASTREE sensor showed that the uradome tips had a stronger umami taste than the bamboo shoots from Yamagata Prefecture. On the other hand, TS-5000Z analysis showed that during the first taste, umami was weaker than that of the bamboo shoots, while the aftertaste of umami was stronger than that of the bamboo shoots. These results suggest that the umami output data produced by α ASTREE is likely to be similar to that of the aftertaste data from the TS-5000Z analysis. Umami and richness (aftertaste) indicate the persistent fullness presented by umami substances [13]. The persistent richness of the taste is also considered to be a major characteristic of the uradome tips, as is the weak egumi taste.



Free amino acid analysis

Figure 5 shows the analysis of 18 free amino acids in uradome tips and bamboo shoots collected from the same bamboo forest in Yamanobe Town. Cystine was not detected in any of the samples, but 17 other free amino

acids were detected (Fig. 5). Five amino acids (tyrosine, proline, glutamic acid, aspartic acid, and tryptophan) were more abundant in the bamboo shoots than in the uradome tips, methionine abundance was almost the same in both the uradome tips and bamboo shoots, and

the other 11 amino acids were more abundant in the uradome tips (Fig. 5).

Of the 18 free amino acids analyzed in this study, nine are essential amino acids that cannot be biosynthesized by the body (leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, and histidine) [14]. The nutritional value of protein, which is composed of amino acids linked by peptide bonds, is evaluated by the composition of the constituent amino acids, especially the balance of essential amino acids [14], and a high content of essential amino acids can be an advantage in food sources. The results of this study showed that eight of the nine essential amino acids (excluding tryptophan) were found in the uradome tips and were in similar quantities as those in the bamboo shoots (Fig. 5). Therefore, the edibility potential of uradome tips is increased due to their higher essential amino acid content.

In addition, leucine was detected only in the uradome tips (Fig. 5). Leucine is a commonly known branched-chain amino acid; branched-chain amino acids are considered to have physiological functions in enhancing muscle protein synthesis [14]. Leucine, which is generally recognized as a functional and essential amino acid, can be obtained from uradome tips, and this is considered to be a favorable feature of uradome tips when compared to bamboo shoots.

Glutamate is the most important free amino acid, with respect to umami [8]. The glutamate content was higher in the bamboo shoots than in the uradome tips (Fig. 5). It is assumed that this result is related to the results of the TS-5000Z analysis, which showed that the umami (first taste) value of the uradome tips was smaller than that of bamboo shoots (-0.91 with bamboo shoots at 0). On the other hand, some tripeptides that are composed of three amino acids have umami and richness characteristics, such as γ -glutamyl-valyl-glycine [15]. The amino acids that make up γ -glutamyl-valyl-glycine are glutamate, valine, and glycine. In this study, glutamate content was lower in the uradome tips, whereas valine and glycine were higher. Thus, it is possible that the umami and richness associated with the continued aftertaste of uradome tips were strong.

Furthermore, in this study, a higher amount of tyrosine was detected in both the bamboo shoots and the uradome tips compared to the other free amino acids. In grasses, there is an additional pathway for lignin biosynthesis via L-tyrosine [16]. In bamboo shoots, the activity of ammonia lyase, which catalyzes the deamination reaction of L-thyronine to *p*-coumaric acid, is remarkably high from the tip to the base of the culm [16]. In addition, the pathway through L-tyrosine plays a very important role in moso bamboo, which is a unique pathway not found in other plants [17]. A study of internode

growth and tyrosine distribution showed that the greatest amount of tyrosine was contained near the inflection point of the internode growth curve, and a large amount of tyrosine was pooled in the area where the internode was about to be extended by cell division and elongation [17]. The authors have previously reported on the cell wall composition components of the uradome portion and that of early elongating bamboo shoots [5]. In that report, Klason lignin wasn't detected in the early elongated bamboo shoots, while its composition of uradome portion was 7–10%, suggesting that the uradome stage is the initial stage of lignin polymerization and deposition [5]. Therefore, it is possible that tyrosine is pooled more in bamboo shoots, where lignin polymerization is about to start, than in the tip of uradome, where lignin polymerization is already in progress.

Conclusion

The results of this study demonstrate the edibility potential of uradome tips, both in terms of taste and amino acid content. In this study, we analyzed amino acids, which are thought to have a significant effect on taste, but it is necessary to analyze other components, such as sugars and fatty acids, in order to characterize the food. In addition, physical properties such as texture and hardness should also be investigated in the future to further explore the edibility potential of uradome tips.

Abbreviation

NMS: This is the name of the sensor that measures umami taste and is one of the seven sensors that the taste sensor α ASTREE has.

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Author contributions

YF was responsible for all the experiments and writing; HK provided advice on the amino acid analysis; TA provided advice on the chemical analysis and discussion. All authors read and approved the final manuscript.

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Availability of data and materials

All the data generated and analyzed in this study are included in this published article.

Declarations

Competing interests

The authors declare that they have no competing interests.

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