Study of quality evaluation of aroma in potherbs belonging to the Lamiaceae family

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Study of quality evaluation of aroma in potherbs belonging to the Lamiaceae family

(シソ科ハーブ香気の品質評価手法についての研究)

Graduate school of Natural Science and Technology

Division of environmental science and engineering

Environmental dynamics

Takehito Sagawa

Abstract

Plants belonging to the Lamiaceae family are well-known potherbs that are used in food and as herbal teas for their characteristic aroma, the sources of which are the essential oils filled in the peltate glandular trichomes (PGTs). In this study, we attempted to combine gas chromatography (GC) with other analysis methods such as tissue structure observation and rheological analysis for obtaining a better correlation between the results of physicochemical analysis and sensory evaluation on plants belonging to the Lamiaceae family. Furthermore, the direct sample introduction GC-MS method, which did not require the extraction of aroma compounds, could be used for the quantitative analysis of aroma compounds contained in individual PGTs from small pieces of leaves. We demonstrated that the perceived aroma of potherbs from the Lamiaceae family is influenced by various factors and that the same essential oils are not uniformly distributed in the PGTs. Subsequently, we developed a method to analyze the essential oil content of individual PGTs and to confirm the distribution of the aroma compounds. This study suggested that the use of different approaches allowing both macro- and microlevel observations on aroma compounds of Lamiaceae potherb was a successful approach.

Summary

Among the five traditionally recognized senses in humans, the sense of smell has an important function. Humans have long been using aromas derived from plants for different purposes, namely, for charging food with potherbs or tasting beverages such as herbal tea. Plants belonging to the Lamiaceae family are well-known potherbs used in food and as herbal teas for their characteristic aroma.

While both fresh and dried potherbs are commonly used, the former are preferred because of the distinct and mild aroma they impart, but they have a short shelf life. Dried potherbs, on the other hand, have a long shelf life, but their perceived aroma frequently differs from that of fresh potherbs as a consequence of the drying process. Therefore, dried potherbs with a perceived aroma similar to that of fresh herbs are desirable; further, the high quality of the aroma in dried potherbs must be preserved. Different qualities of dried potherb are obtained depending on the drying technique used. Therefore, analytical evaluation of the aroma quality has become important. Usually, the first step of such evaluation involves analyzing the essential oil present in the dried potherb; however, many factors influence the results of sensory evaluations. In some cases, it is difficult to correlate the results of qualitative and quantitative chemical analyses with the perceived aroma.

There are some explanations for the limited correlation between the chemical analysis results and the sensory evaluation results. First, some aroma compounds that are detected by chemical analysis do not necessarily contribute to the perceptive aroma characteristic; moreover, individual aroma compounds contribute to different extents to the aroma characteristic. Second, the abundance ratio of aroma compounds often makes a more notable contribution to the overall aroma characteristic than does their total content. "Flavor release" during the consumption of a given food or drink indicates that the abundance ratio of the aroma compounds released is sometimes different. Therefore, flavor release from food also contributes to the perception of the aroma. However, there are no analytical methods for the accurate detection of aroma compounds released from foods, owing to the biases associated with the extraction devices, such as the partition coefficient of individual aroma compounds in the given device.

In this study, we tried to combine gas chromatography (GC) with other approaches such as tissue structure observation and rheological analysis for obtaining a better correlation between the results of physicochemical analysis and sensory evaluation, by using plants belonging to the Lamiaceae family. First, we performed macroanalysis to determine the differences in the aroma quality of fresh and three types of dried potherbs (air-dried, freeze-dried, and

vacuum-dried sweet basil) by using a combination of GC with tissue structure observation and rheological analysis and determined the convenience of using these different approaches. Next, we focused on the essential oils and peltate glandular trichomes (PGTs) accumulated within the essential oils of a plant belonging to the Lamiaceae family and confirmed the relationship between aroma perception and the essential oils accumulated in the PGTs. The plants of the Lamiaceae family contain a large number of PGTs on the upper and lower surfaces of their leaves. We performed X-ray computed tomography (X-ray-CT) imaging and chemical analysis of the essential oils of rosemary. Rosemary was used as the analytical sample because of its high PGT content. The extraction of the essential oils from rosemary PGTs was straightforward. Thus, from these two analyses, we demonstrated that the perceived aroma of potherbs of the Lamiaceae family is influenced by various factors and that the PGTs did not uniformly contain the same essential oils. As the last step, we developed a method to analyze the essential oil content of individual PGTs and to confirm the distribution of the aroma compounds.

Our results provided the following useful information. (1) Gas chromatographic analysis of hot-water extracts proved to be a useful approach, because the analytical results in this case could be explained by the results of sensory evaluation of the herbal teas (Fig. 1). For the aroma of the

dried potherbs, a correlation was established between the observations and the results of GC and rheological analysis of the leaf tissue structures. (2) Observation of the PGTs and the basal tissue under each PGT through X-ray CT revealed that the PGTs at different locations (i.e., on the lower or upper surface of a leaf) had different structures of basal tissue in rosemary (Fig. 2). Moreover, we confirmed that PGTs located on the upper and lower surface of a leaf and those on the stem contained different types of essential oils (Fig. 3). These findings revealed that observation and physiological analysis related to the chemical analysis of aroma compounds were useful approaches for evaluating the aroma quality in potherbs of the Lamiaceae family.

Furthermore, the direct sample introduction GC-MS method, which did not require the extraction of aroma compounds, could be used for the quantitative analysis of aroma compounds contained in individual PGTs from small pieces of leaves (Fig. 4). These results suggested that chemical analysis can explain the characteristics of aroma perceived using the various approaches adopted in this study.

It is considered that specific aroma compounds may not be distributed uniformly in cooking foods and that the difference in the physicochemical properties of cooking foods might influence the aroma released from the foods during their consumption. Therefore, the various

approaches used in this study are expected to complement the sensory evaluation of cooking foods.

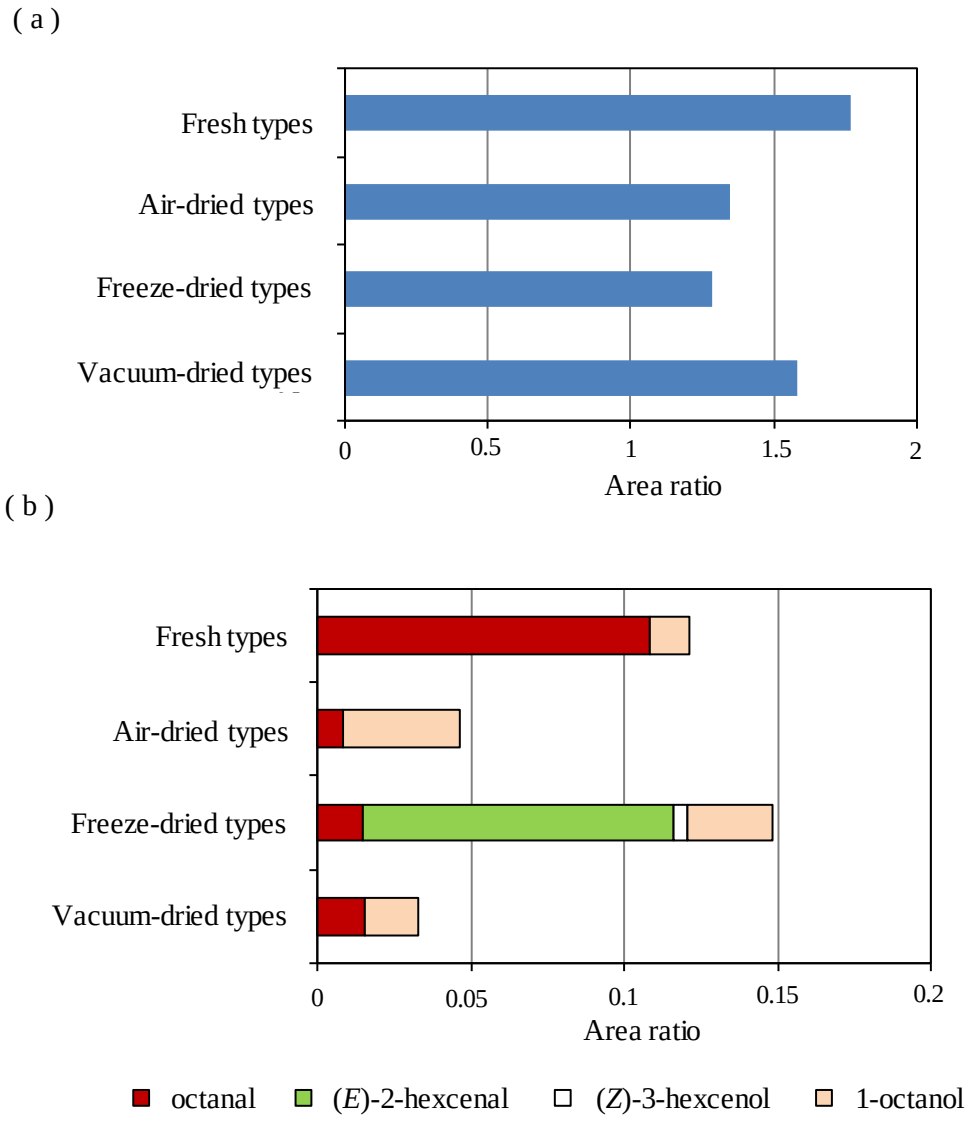

Fig. 1 Quantitative values of main and minor aroma compounds in fresh and dried sweet basil teas.

(a) main aroma compounds; ratio of linalool and 1,8-cineole (linalool/1,8-cineole), (b) minor aroma compounds; octanal, (*E*)-2-hexcenal, (*Z*)-3-hexcenol, 1-octanol.

(Number of replications = 3).

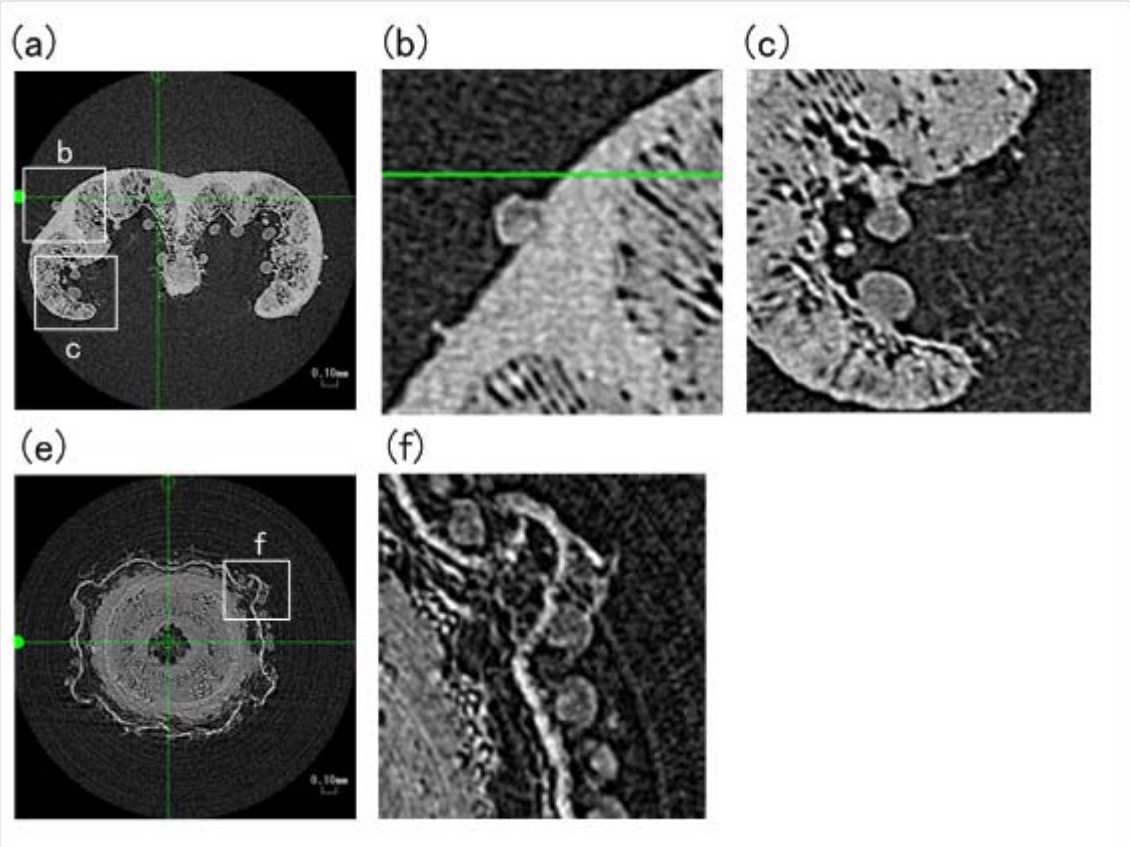

Fig. 2 X-ray CT images of PGTs. (a) leaf, (b) PGT on the upper surface of a leaf, (c) PGT on the lower surface of a leaf, (e) stem, (f) PGT on the surface of a stem.

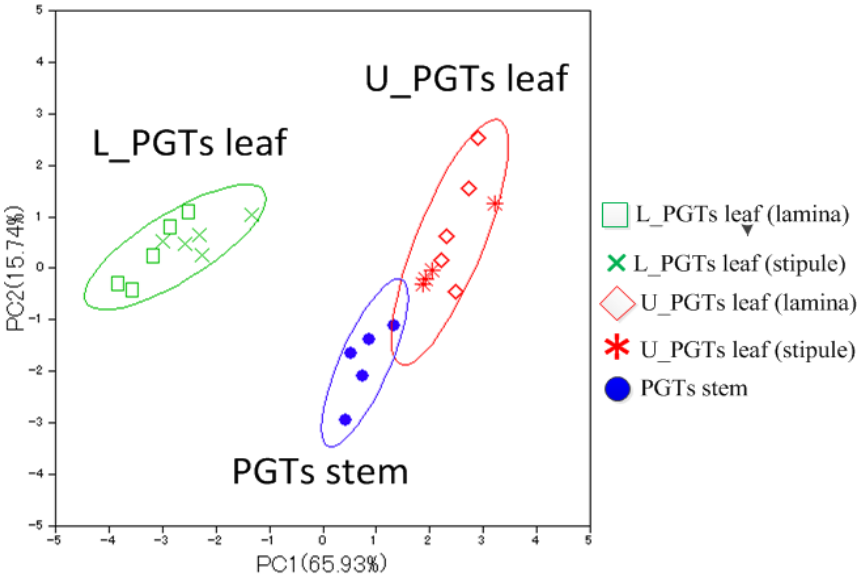

Fig. 3 Principal component analysis score plot of essential oils in each type of PGT. Probable ellipses (P = 0.95) were calculated by hierarchical cluster analysis with PC1 and PC2 scores. L_PGTs: peltate glandular trichomes on the lower surfaces of leaves. U_PGTs: peltate glandular trichomes on the upper surfaces of leaves. PGT stem: peltate glandular trichomes on the surface of stems.

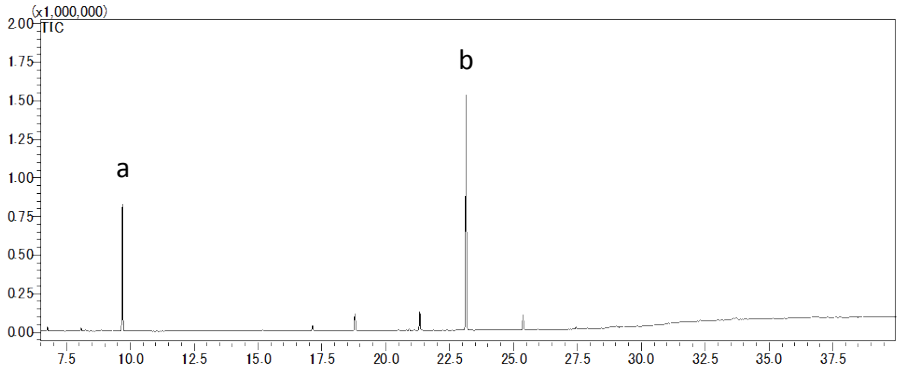

Fig. 4 Total ion chromatogram of a piece of leaf tissue with a peltate glandular trichome (PGT) of the green perilla. a) limonene, b) perillaldehyde.

学位論文審査結果の要旨

［審査経過］審査方針に従い、基礎学力を確認し、各委員による面接と諮問を行った。8 月 5 日に口頭発表（最終試験）を行い、終了後に開催した最終審査委員会において協議の結果、次のように判定した。

［審査結果］ハーブの香りの評価では、精油成分の機器分析も行われているが、官能試験に頼るところが大きい。本研究は、両者の相関性が高い方法の開発を目的として、シソ科ハーブを材料とし、GC と組織観察やレオロジー計測などの組み合わせの評価を行った。先ず、乾燥品と生のスィートバジルの GC 測定、組織観察、貯蔵弾性率測定を行い、熱水抽出物の香気特徴成分を GC-olfactmetry で分析した結果、本法は香気特徴を説明可能であり、熱水抽出法は有用な処理方法であることがわかった。また、組織構造観察や貯蔵弾性率も有用であった。次に、精油が蓄積されている楯状腺毛 (PGT) について、精油成分の化学分析だけではなく、X-ray computed tomography を用いた非破壊構造観察を組み合わせて解析した結果、これらの方法も評価に有用なことがわかった。最後に、特別な抽出操作を行わずに PGT 含有香気成分を試料部位から直接採取して分析できる方法として direct sample introduction - GC/MS 分析を開発した。本法は、PGT の存在部位を 100 μm の単位で分取でき、主要 6 香気成分（limonene, perillaldehyde, 1,8-cineole, linalool, eugenol, l-carvone）も 10 ～ 1000 ng の範囲で定量（相関係数 0.99 以上）可能になった。開発した本法は、シソ科ハーブ香気の品質評価を行う上で有効な解析手法である。よって、審査委員会は博士（薬学）に値すると判定した。