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Gas Chromatography Mass Spectrometry

Metabolite and Sensory Differences of Soy-Sauce-Like Seasoning Produced from Different Raw Materials

Abstract

Soy sauce is an important traditional Japanese condiment, which primarily functions to provide umami taste. It is commonly produced from soybeans, wheats, and salt water. In recent years, diversification of soy-sauce-like seasonings has been done through the production using other raw materials, such as rice and peas, has recently been developed. In this study, a combination of GC-MS based component profiling and paired comparison test were used to evaluate the effect of raw materials on the component profile and umami taste in five grain-based and four bean-based soy-sauce-like seasonings. PCA results showed that grain-based samples and bean-based samples were separated along the PC1 axis (accounting for 48.1 % of the total variance). Consistent with previous reports, grain-based samples were distinguished by saccharides, such as glucose and trehalose, while bean-based samples were characterized by amino acids, such as glutamic acid. Sensory evaluation by means of paired comparison test showed that bean-based samples had a stronger umami taste than grain-based samples. Accordingly, it is possible that the carbohydrate and protein content in raw materials determine the component profiles of soy-sauce-like seasoning and have an effect on the umami intensity. This is the first detailed metabolomics study of the characteristic compounds and umami of a variety of soy-sauce-like seasonings made from different raw materials.

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Materials

Soy-sauce-like-seasoning made from a single type of grain or a single type of bean were used as samples. The samples were stored at 4 °C until use.

Table 1 List of soy-sauce-like seasoning samples

Sample number	Sample name	Raw materials	Classifications
1	Rice *shoyu*	Rice	Grain
2	Awa *shoyu*	Foxtail millet	
3	Hie *shoyu*	Barnyard millet	
4	Kibi *shoyu*	Millet	
5	Quinoa *shoyu*	Quinoa	
6	Soramame *shoyu*	Broad bean	Bean
7	Kuromame *shoyu*	Black bean	
8	Endomame *shoyu*	Pea bean	
9	Marudaizu *shoyu*	Soy bean, wheat	

Derivatization and GC-MS Analysis

Before derivatization, the samples were diluted with ultrapure water by 10-fold. Then, 60 µL of ribitol (0.2 mg/mL) was added as the internal standard to 20 µL of the diluted sample. The mixture was then lyophilized for overnight.

Derivatization process used in this experiment was oximation using 100 µL of methoxyamine hydrochloride (20 mg/mL) with incubation for 90 minutes at 30 °C and silylation using 50 µL of N-methyl-N-trimethylsilyl-trifluoroacetamide (MSTFA) with incubation for 30 minutes at 37 °C. Derivatized samples were subjected to GC-MS analysis using a Shimadzu GCMS-QP™2010 Ultra.

Table 2 GC-MS analysis conditions

Injection volume	: 1 µL
Column	: InertCap 5 MS/NP Column (30 m, 0.25 mm i.d., 0.25 mm film thickness, GL Sciences)
Split mode	: 25:1 (v/v)
Injection temperature	: 230 °C
Carrier gas	: He
Carrier gas flowrate	: 1.12 mL/min with liner velocity 39 cm/s
Column temperature	: 80 °C for 2 min Increased 15 °C/min to 330 °C 330 °C for 6 minutes
Interface temperature	: 250 °C
Ion source temperature	: 200 °C
Ionization	: Electron Ionization (EI)
Mass range	: *m/z* 85-500
Retention index	: Standard alkane mixture (C_8– C_{40})

PCA

A GC-MS analysis was conducted for low-molecular-mass, hydrophilic compounds. A total of 133 compounds were annotated, and PCA was conducted using these annotated compounds. Results are shown in Fig. 1 and Table 3, and suggests that soy-sauce-like seasoning made from grains contained high amounts of saccharides, while samples made from beans contain high amounts of amino acids.

Sensory Evaluation

Paired comparisons was used to investigate the taste intensity of umami and sweetness of grain-based and bean-based samples. Bean-based samples tended to have more intense umami taste than grain-based samples (Fig. 2a). This may be due to the higher intensity of glutamic acid in bean-based samples. The panelists detected no significant difference in sweetness between the sample types (Figs. 2b, 2c).

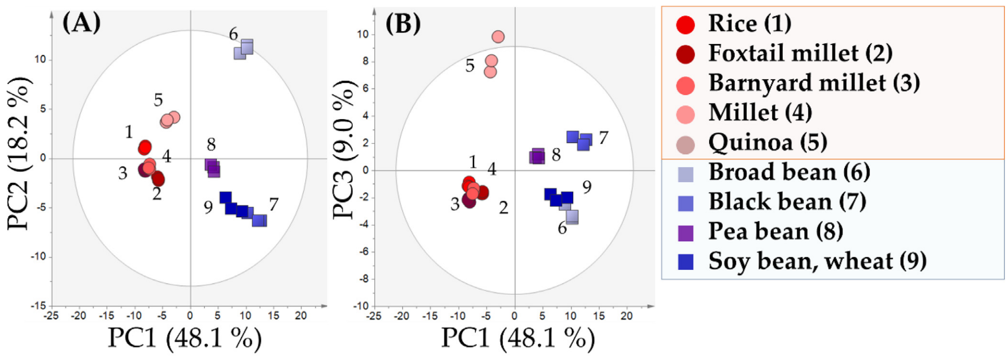

Fig. 1 PCA result for soy-sauce-like seasoning samples. Points and labels indicate samples and sample number, respectively. Circle and square dots represent grain-based samples, and bean-based samples, respectively. (A) PCA score plot for PC1 and PC2. (B) PCA score plot for PC1 and PC3.

Table 3 Compounds with factor loadings (as absolute values) greater than 0.1 for each PC1. Compounds plotted on the positive side (A) and negative side (B) are shown below.

(A) Compound	*p(corr)*[PC1]	Compound	*p(corr)*[PC1]
β-Alanine	0.1242	Galactose	0.1174
Phenylalanine	0.1241	Allose	0.1174
β-*N*-Methyl amino alanine	0.1237	Hypoxanthine	0.1168
Glycine	0.1237	Dihydroxyacetone	0.1160
Isoleucine	0.1237	Unknown	0.1142
Valine	0.1235	Inositol	0.1136
Threonine	0.1234	Xylonic acid	0.1116
Lysine	0.1234	Alanine	0.1107
Phosphoric acid	0.1232	Pyroglutamic acid	0.1100
Leucine	0.1230	Tyrosine	0.1097
Maleic acid	0.1228	Xanthine	0.1084
Glutamic acid	0.1227	Histidine	0.1077
5-Aminovaleric acid	0.1225	Cysteine	0.1050
N-α-Acetyl ornithine	0.1223	Unknown	0.1049
N-α-Acetyl lysine	0.1215	Xylitol	0.1048
Proline	0.1215	Alanyalanine	0.1045
Normetanephrine	0.1211	Methionine	0.1040
2-Aminoethanol	0.1203	Unknown	0.1039
2-aminoadipic acid	0.1203	Uracil	0.1033
Glycolic acid	0.1197	Malonic acid	0.1022
Serine	0.1197	Mannose	0.1021
Thymine	0.1186	Phthalic acid	0.1007
Lyxose	0.1184	-	-
(B) Compound	***p(corr)*[PC1]**	**Compound**	***p(corr)*[PC1]**
Glucose	-0.1193	*N*-Acetyl	-0.1091
Unknown	-0.1161	Galactosamine	-0.1067
Glyceryl-glycoside	-0.1148	Trehalose	-0.1038
Thymidine	-0.1131	β-Lactosebe	-0.1036
Melibiose	-0.1107	Lactitol	-0.1034

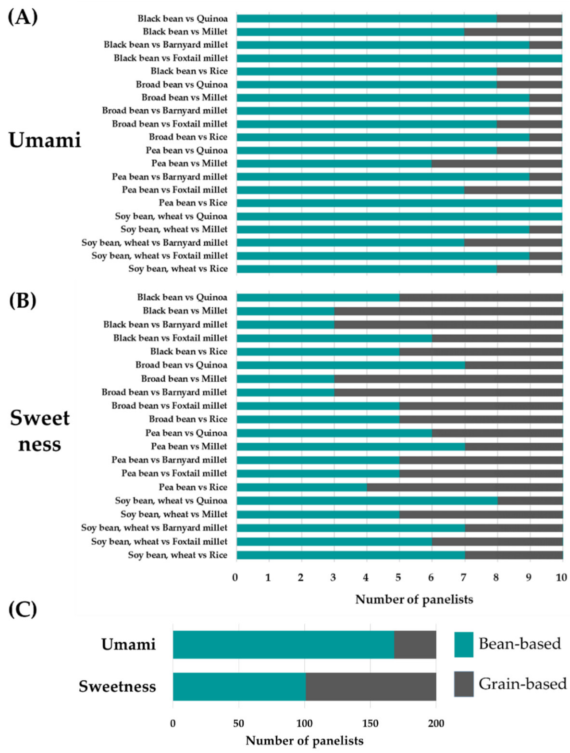

Fig. 2 Bar graph result for paired comparisons test for the intensities of umami and sweetness between grain-based and bean-based samples. (A), (B) Number of panelists that selected each sample in pairwise comparisons. (C) Total number of panelists that selected soy-sauce-like seasonings made from grain and based on umami and sweetness.

Conclusion

The results from this study may benefit the pineapple industry in the development of new products using different raw materials to meet various consumer needs.

<References>
Previously published in Yamana T., Taniguchi T., Nakahara T., Ito Y., Okochi N., Putri SP., Fukusaki E. Component Profiling of Soy Sauce-like Seasoning Produced from Different Raw Materials. Metabolites. 2020;10(4):134. Published 2020 April 1. doi:10.3390/metabo10040137

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