Soy Sauce and Traditional Local Dishes

Regional Characteristics of Soy Sauce Identified by Analytical and Sensory Properties

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I. Introduction

Japanese soy sauce is defined under Japanese Agricultural Standards (JAS) as *koikuchi* (common), *tamari* (tamari), *usukuchi* (light-colored), *saishikomi* (re-fermented), or *shiro* (extra-light-colored). In addition, there is a *dashi* soy sauce (soy sauce blended with dashi) that is sometimes used outside of the five types listed.[1)] Among these five types, koikuchi accounts for roughly 80 percent of the soy sauce consumed in Japan, and is said to vary by region in terms of characteristics such as saltiness and sweetness.[1)] Despite this widely held perception, no report has yet scientifically examined actual regional differences in soy sauces. Thus, for the purpose of scientifically elucidating regional characteristics of soy sauce, we conducted a component analysis and sensory evaluation of soy sauces consumed in individual regions throughout Japan.

II. Component Analysis

To study the characteristics of soy sauce consumed in each region, we prepared a list of soy sauce products that sell well by region, and used the mean value of the top five products in each region as the component value representing that region. The regions and the total market share of the top five products in each region are as follows:

Hokkaido (44.3%), Tohoku (41.7%), Hokuriku (26.9%), Outlying Areas in Kanto (Kanto Region excluding the Tokyo Metropolitan Area) (38.2%), Tokyo Metropolitan Area (Tokyo Metropolis and three neighboring prefectures) (44.2%), Chukyo (44.2%), Kinki (49.4%), Chugoku (27.0%), Shikoku (40.9%), and Kyushu (19.1%). *We compiled samples based on data from the Nikkei POS Information Service (soy sauce category from 2011 to 2013, except for Hokuriku, for which we used data from 2012 to 2013).

A general analysis of soy sauce usually examines the total nitrogen, salt concentration and color, which are referred to by the JAS. Although no particular trends by region were found among these factors, except for salt concentration, interesting trends were noted in components related to the flavor of the soy sauce, such as sweetness, brewed aroma (HEMF), and umami (savory taste). Findings for these components, as well as salt concentration, are outlined below.

[Salt Concentration (Saltiness)]

Soy sauce consumed in the Tokyo Metropolitan Area and Outlying Areas in Kanto has higher salt concentrations, which shows that salty soy sauce is favored in these regions. In contrast, dashi soy sauce such as kombu (kelp) soy sauce tends to be favored in Hokkaido, while low-sodium soy sauce is ranked as one of the more popular products in Kinki, meaning salt concentration is lower in these regions. In Kyushu, soy sauce products generally have lower salt concentrations. (Figure 1)

|: Range of values from minimum to maximum

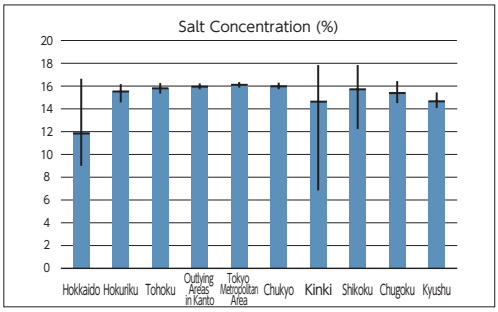

Figure 1 Mean salt concentration of the five bestselling products in each region

[Sugar Concentration, Glycyrrhizin Concentration (Sweetness)]

Concentrations of major monosaccharides, sucrose (a disaccharide) and glycyrrhizin (the chief sweetness constituent of licorice) contained in soy sauce were measured to express sweetness in terms of glucose. The total converted values were then compared between regions. The results showed that soy sauce used in Kyushu was far sweeter than its counterparts in other regions, with its sweetness value being almost double that of soy sauce used in the second and subsequent regions. In terms of sweetness, Kyushu was followed by Chugoku and Shikoku, while the soy sauce in Tohoku, Outlying Areas in Kanto, the Tokyo Metropolitan Area, and Chukyo tended to have the least sweetness. (Figure 2)

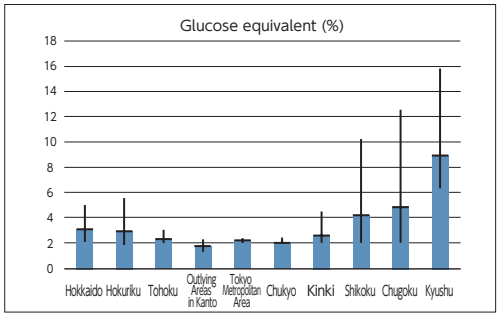

Figure 2 Mean glucose equivalent of sweetness constituents concentrations in the five bestselling products in each region

[Levulinic Acid Concentration (Hydrolyzed Vegetable Protein)]

Levulinic acid is a substance generated when sugar is

hydrolyzed with hydrochloric acid. As levulinic acid is not found in brewed soy sauce (manufactured by fermentation), it is used as a component to be analyzed to determine whether a soy sauce contains hydrolyzed vegetable protein. Levulinic acid content indicates that soy sauce used in Hokuriku, Tohoku, Chugoku and Kyushu is manufactured by a mixing method or by a semi-fermentation method. (Figure 3)

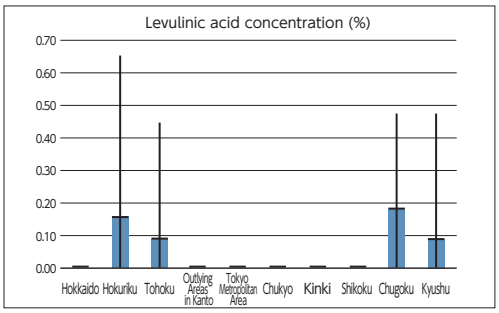

Figure 3 Mean levulinic acid concentration of the five bestselling products in each region

[HEMF Concentration (Brewed Aroma of Soy Sauce)]

In Hokuriku, Tohoku, Chugoku and Kyushu, where soy sauce containing levulinic acid is favored, the soy sauce contains hydrolyzed vegetable protein, and the brewed soy sauce content is smaller. Therefore, soy sauce in these regions tends to have less HEMF (4-Hydroxy-2(5)-ethy-5(2)-methyl-3(2H)-furanone), which is the typical aroma of brewed soy sauce. Soy sauce in Hokkaido is considered to have a low mixed ratio of fermented soy sauce, as dashi soy sauce is common in the region. Soy sauce used in Outlying Areas in Kanto and the Tokyo Metropolitan Area, Chukyo and Kinki has a high HEMF concentration, indicating that brewed soy sauce is favored in these regions. (Figure 4)

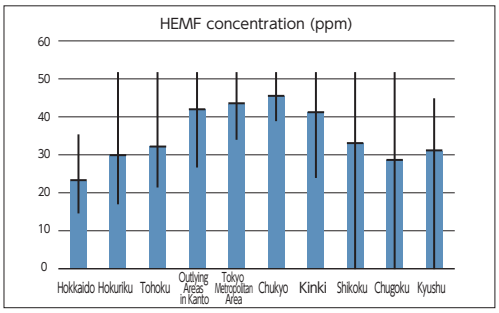

Figure 4 Mean HEMF concentration of the five bestselling products in each region

[Glutamic Acid Concentration,Nucleic Acid Concentration (Umami)]

Monosodium glutamate (MSG) and nucleic acid (guanosine monophosphate (GMP), and inosine monophosphate (IMP)) work synergistically to increase umami.Many soy sauce products in Hokuriku, Chugoku, Shikoku and Kyushu impart a prominent umami, as they have well-balanced monosodium glutamate and nucleic acid content. In contrast, fewer soy sauce products in the Tokyo Metropolitan Area, Outlying Areas in Kanto, Chukyo and Kinki contain nucleic acid. (Figure 5)

The MSG equivalent of umami intensity = u + 1200u × v, where u is MSG concentration (g/dl), v is IMP concentration (g/dl), and the umami intensity of GMP is 2.3 times that of IMP.[2]

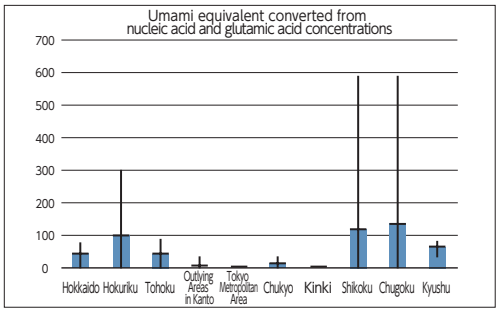

Figure 5 Umami equivalent converted from mean value of nucleic acid and glutamic acid concentrations of the five bestselling products in each region

[Summary]

Hokkaido: The salt content is rather low and umami is prominent, which is attributable to the prevalence of dashi soy sauce. The brewed aroma is the most subdued of all the regions.
Tohoku: The salt content is high and sweetness is subdued, while the hydrolyzed vegetable protein keeps the umami rather prominent.
Hokuriku: The salt content is high, umami is prominent, and sweetness is more prominent than in Kanto.
Outlying Areas in Kanto: The salt content is high, and sweetness is subdued. Brewed soy sauce prevails.
Tokyo Metropolitan Area: The salt content is high, and sweetness is subdued. Brewed soy sauce prevails.
Chukyo: Somewhat similar to Outlying Areas in Kanto and the Tokyo Metropolitan Area, as sweetness and umami are subdued and hydrolyzed vegetable protein is not used.
Kinki: Sweetness and umami are subdued, and there is no hydrolyzed vegetable protein present, but the salt content varies among products.
Shikoku: The umami is prominent, and sweetness is rather prominent as well, but the soy sauces contain no hydrolyzed vegetable protein. Salt content is not low.
Chugoku: Sweetness is prominent, and umami is the most prominent of all regions, while the brewed aroma is subdued. Hydrolyzed vegetable protein is used.
Kyushu: Sweetness is the most prominent of all regions and the umami is prominent as well, while the salt content is lower. Hydrolyzed vegetable protein is present.

Ⅲ. Sensory Evaluation

[Groupings of Soy Sauce Products from Individual Regions and Sensory Characteristics of Each Group]

As with the aforementioned component analyses, we compiled samples based on data from the Nikkei POS Information Service (soy sauce category from 2011 to 2013, except for Hokuriku, for which the data was from 2012 to 2013). Five bestselling samples were selected from each of the ten regions (Hokkaido, Tohoku, Hokuriku, Outlying Areas in Kanto, Tokyo Metropolitan Area, Chukyo, Kinki, Chugoku, Shikoku, and Kyushu). Where the total share of the five bestselling samples amounted to less than 40% (Hokuriku, Chugoku and Kyushu), up to 5 samples were added so that the total share in the region reached 40%. Thus, a total of 62 samples were subjected to evaluation. Each sample was evaluated by quantifying the intensity of the following 13 properties on a 9-point -scale(scoring): alcohol smell, refreshing smell, pickled *daikon* radish smell, kombu smell, *katsuobushi* (dried

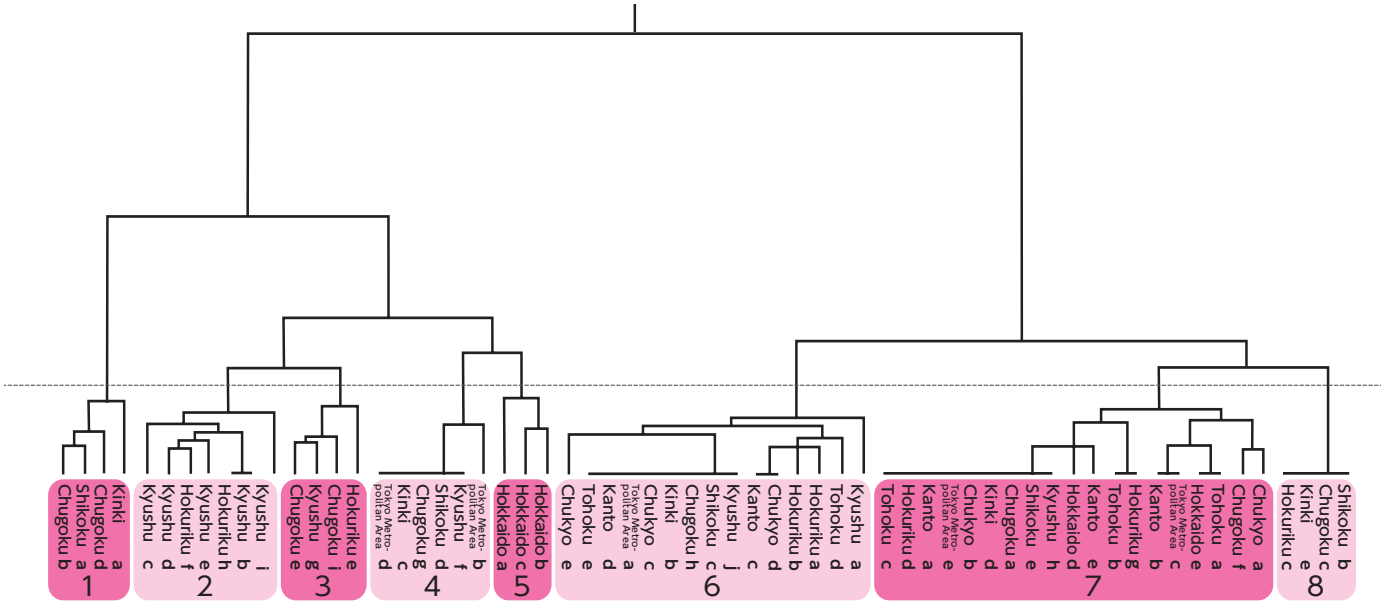

Figure 6 Dendrogram representing the results obtained by hierarchical cluster analysis (Ward's method)

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Prominent properties	Katsuobushi smell Kombu flavor Katsuobushi flavor Mellowness Umami Sweetness Stickiness	Pickled daikon radish flavor Kombu flavor Katsuobushi flavor Mellowness Umami Sweetness Stickiness	Kombu flavor Katsuobushi flavor Mellowness Umami Stickiness		Kombu smell Kombu flavor Mellowness Umami Sweetness	Pickled daikon radish smell Saltiness	Alcohol smell Refreshing smell Saltiness
Subdued properties	Alcohol smell Refreshing smell Pickled daikon radish smell Saltiness		Alcohol smell Refreshing smell	Katsuobushi flavor Saltiness Stickiness	Alcohol smell Pickled daikon radish smell Saltiness	Katsuobushi flavor	Kombu smell/flavor Katsuobushi smell/flavor Pickled daikon radish flavor Mellowness Umami Sweetness Stickiness
Characteristics	Prominent katsuobushi smell	Prominent pickled daikon radish flavor		Subdued katsuobushi flavor and stickiness	Prominent kombu smell	Prominent pickled daikon radish smell	Prominent pungent smell (alcohol smell and refreshing smell).
	Prominent kombu flavor, mellowness and umami, and subdued saltiness					Prominent saltiness	

Table 1 Sensory characteristics of each group: Prominent properties and subdued properties identified by tests for significant differences (Kruskal-Wallis test, Steel test $p<0.05$)

skipjack tuna shavings) smell, pickled daikon radish flavor, kombu flavor, katsuobushi flavor, mellowness, saltiness, umami, sweetness, and stickiness. The panel consisted of 50 women, aged 25 to 58, selected from among general consumers using the criteria of sense of smell, gustatory sensitivity, and ability to discern soy sauces.

Cluster analysis of the intensity data regarding the 13 properties resulted in dividing the 62 samples into two broad groups, and further into eight small groups (Figure 6). Test results for significant differences revealed perceived sensory characteristics for each group (Table 1). Groups 1 to 5 were characterized by a prominent kombu flavor, mellowness, and umami, and subdued saltiness. In particular, Group 1 had a prominent katsuobushi smell, Group 2 had a prominent pickled daikon radish flavor, Group 4 had subdued katsuobushi flavor and stickiness, and Group 5 had a prominent kombu smell. Groups 6 and 7 were characterized by intense saltiness. In particular, Group 6 had a prominent smell of pickled daikon radish and Group 7 had prominent pungent smell. Group 8 was not subjected to characterization by tests for significant differences, because the group consisted of one sample.

[Perceived Sensory Characteristics of Soy Sauces in Individual Regions]

The total share of each group was computed by region, and is shown in descending order of share value in Figure 7. The ten regions were classified into the following three zones according to how salty-type soy sauce (Groups 6 and 7) that is commonly found in many regions is consumed.

(1) Regions where only salty-type soy sauce (Groups 6 and 7) is consumed: Tohoku, Outlying Areas in Kanto, and Chukyo

Among salty types of soy sauce, the prevalence of consumption was in order of Group 7 (prominent pungent smell) and Group 6 (prominent pickled daikon radish smell) in Tohoku and Outlying Areas in Kanto, while it was in the reverse order in Chukyo.

(2) Regions where both salty and other types of soy sauce are consumed: Hokuriku, Tokyo Metropolitan Area, Kinki, and Shikoku

In Hokuriku salty-type Groups 6 (prominent pickled daikon radish smell) and 7 (prominent pungent smell) were followed by Group 2 (prominent pickled daikon radish flavor), which has a prominent kombu flavor, mellowness and umami, and subdued saltiness, and then by Group 3, and finally by Group 8.

In the Tokyo Metropolitan Area, after salty-type Groups 7 (prominent pungent smell) and 6 (prominent pickled daikon radish smell), Group 4 (subdued katsuobushi flavor and stickiness), which has a prominent kombu flavor, mellowness and umami and subdued saltiness, was most popular.

Kinki and Shikoku had the same order of top three share groups, with the top being Group 7, which has prominent saltiness and pungent smell, followed by Group 8, and then by Group 6, which has prominent saltiness and pickled daikon radish smell. However, the

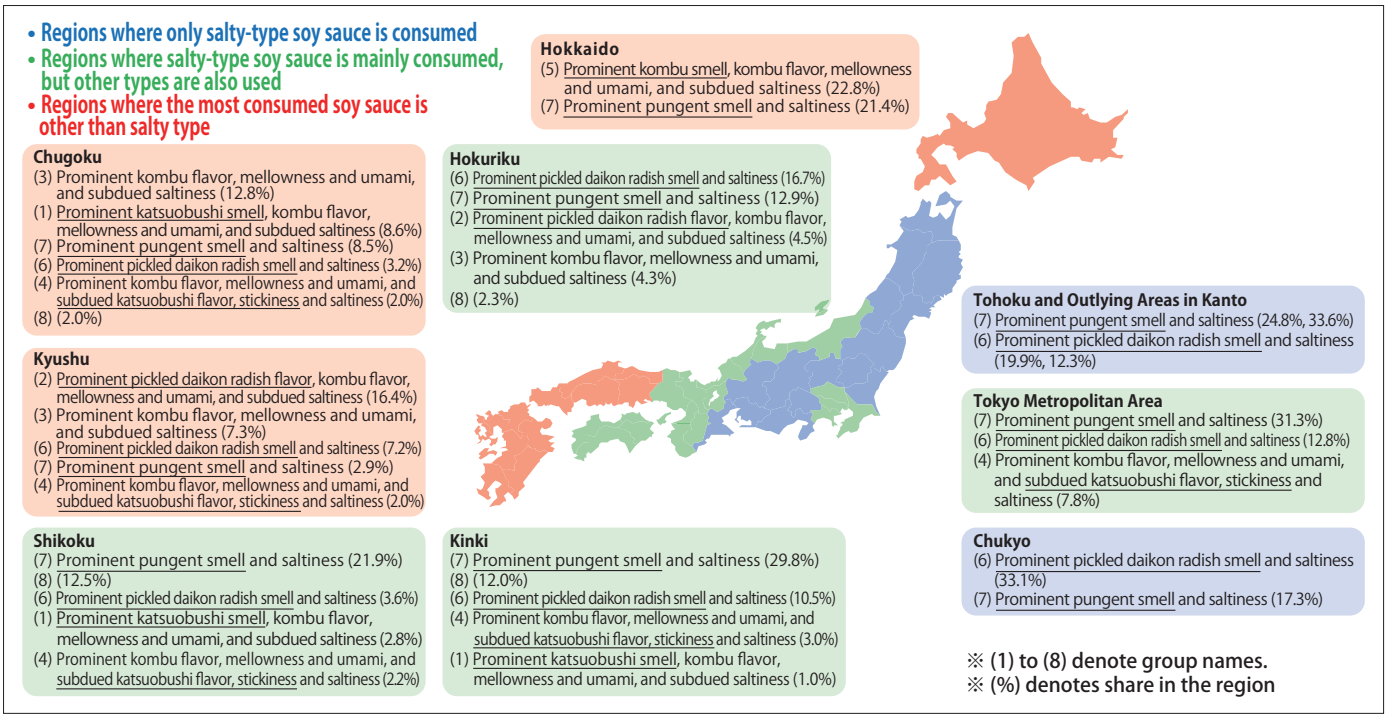

Figure 7 Sensory characteristics of soy sauce consumption in each region

4th and 5th places in Kinki were Group 4 (subdued katsuobushi flavor and stickiness), which has prominent kombu flavor, mellowness and umami, and subdued saltiness, and Group 1 (prominent katsuobushi smell) respectively. These two were in the reverse order in Shikoku.

(3) Regions where soy sauce other than salty type is mainly consumed: Hokkaido, Chugoku, and Kyushu

The most consumed soy sauce in Hokkaido was Group 5 (prominent kombu smell), which has a prominent kombu flavor, mellowness and umami and subdued saltiness, followed by Group 7, which has prominent saltiness and pungent smell. Hokkaido was the only region where Group 5 is used.

In Chugoku, the highest share belonged to Group 3, which has a prominent kombu flavor, mellowness, and umami, and subdued saltiness, followed in descending order by Group 1 (prominent katsuobushi smell), Group 7 (prominent pungent smell), which has prominent saltiness, and Group 6 (prominent pickled daikon radish smell). The 5th most consumed was Group 4 (subdued katsuobushi flavor and stickiness), which has a prominent kombu flavor, mellowness and umami, and subdued saltiness, and Group 8 was 6th.

In Kyushu the top share belonged to Group 2 (prominent pickled daikon radish flavor), which has a prominent kombu flavor, mellowness and umami, and subdued saltiness, followed by Group 3. Following this was Group 6 (prominent pickled daikon radish smell) with prominent saltiness, and then Group 7 (prominent punjent smell). In 5th was Group 4 (subdued katsuobushi flavor and stickiness), which has a prominent kombu flavor, mellowness and umami, and subdued saltiness.

[Summary]

It is clear that the bestselling soy sauces in Japan can be classified into eight groups according to perceived sensory characteristics, and also that ten regions in Japan can be divided into three zones according to the popularity of these eight groups of soy sauce. While most regions mainly use salty-type soy sauces, Hokkaido, Chugoku, and Kyushu mainly use other types. It was also found that the most consumed soy sauce types vary between these three regions. In the future, we would like to elucidate why particular soy sauce cultures were formed in these regions by studying their history, environment, cuisine and other elements.

It has been reported that areas separated by mountains have different food cultures, due to differences in climate and difficulties in exchange.[3] This difference in food cultures may impact soy sauce preferences. In this study we divided Japan into ten regions. By considering more appropriate ways to divide regions in the future, we should be able to clarify regional characteristics in greater detail.

IV. Conclusion

We conducted an analysis of components and sensory evaluations of soy sauce to scientifically elucidate perceived sensory characteristics of soy sauces used in various parts of Japan. Despite differing sampling criteria and results analysis methods used in these two examinations, the following common results appeared:

(a) Soy sauce consumed in each region in Japan is characterized by the intensity of saltiness and umami, in particular.

(b) The Tokyo Metropolitan Area and surrounding regions tend to favor salty soy sauce, while regions farther from the Tokyo Metropolitan Area tend to prefer types with a more prominent umami and sweetness.

For other aspects, different findings were obtained between the two examinations. We see a need to interpret the characteristics of soy sauce in individual regions by comparing the findings from the two examinations.

For examinations in this study we focused on soy sauce itself. However, usually soy sauce is used for cooking and consumed with various other ingredients. In the future, we would like to investigate how the differences in soy sauce characteristics clarified in this study influence food and food culture in the individual regions.

References

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