Katsuobushi dashi (Dried Bonite Broth) that enriches the Edo period cuisine

Nozomu Oginome

Introduction

At the press conference in January 2026, the Minister of Land, Infrastructure, Transport and Tourism announced that the number of overseas tourists visiting Japan in 2025 reached a record high of 42.7 million. A survey on consumption trends of inbound tourists shows that food and beverage expenses are ranked second. Washoku, which interests those tourists, is greatly based on the food culture in the Edo period. [1]
Washoku developed in the Edo period for three reasons.

(1) Pursuit of sophisticated taste by *ryotei* (traditional fine-dining restaurants) focusing on drinking parties (e.g., Momokawa in Nihonbashi, Yaozen in Asakusa, and Hirasei in Fukagawa)
(2) Development and spread of Koikuchi Shoyu (standard soy sauce) and sweeteners such as sugar and *mirin*
(3) Completion of *katsuobushi* (dried bonito or skipjack tuna) production method and improvement in quality of *katsuobushi dashi* (broth)
This article will mainly discuss (premium fully-aged *katsuobushi*) completed as improved *Izubushi* in the late Edo period. [2]

1. History of *katsuobushi*

Along the Japanese coast, *katsuo* (bonito or skipjack tuna) are caught twice a year: in spring when the schools first arrive from the southeast (*hatsugatsuo* — the first catch), and in autumn as they return to their spawning grounds (*modorigatsuo* — the returning catch).

(1) Relationship between *katsuo* and Japanese

Many *katsuo* bones have been unearthed in shell mounds of the Jomon period (14,000–300 BCE) on the coast along the Japan Current. In the north, *katsuo* bones have been also found in archaeological sites around Hachinohe, Aomori. [2]

Nozomu Oginome

Graduated from the Department of Fisheries, School of Marine Science and Technology, Tokai University. After joining Ninben Co., Ltd., he engaged in analysis and safety assessment of *katsuobushi* and new products, basic improvement research of *katsuobushi* and flakes, and applied research of beneficial *katsuobushi* molds at the R&D department. Engaged in development of new seasonings. Chief engineer in quality control and sterilization control. Took office as executive officer, head of R&D Department in 2003 and left office in March 2012. Left the company in March 2026. Organized *katsuobushi* food education class for young children to adults. Former director of the Japan Soysauce Technology Center, former Japan Katsuobushi Association expert member.

During the Ritsuryo period (late 7th c to 10th c), processed products, *katsuo* (dried), *nikatsuo*, and *katsuoirori* (*), were sent to the capital from production areas as *cho* (tax) and presented as offerings to deities, emperor, and aristocrats. *Katsuo* (dried) is raw *katsuo* cut into fillets and sun-dried. *Nikatsuo* is sun-dried *namari* (boiled *katsuo*). *Katsuoirori* is a concentrate made from *namari* broth. No recipes have been found in contemporary literature. Researchers in many different fields are jointly studying them. [4]
In *katsuobushi* production process, the crucial part is *kunkan* (smoke-drying) in which *namari* is dried with smoke of burning hardwood logs and high temperature heat. One of the aims of *kunkan* is to prevent initial rot by bacteria. This step is called *baikan* (smoke-drying).

(*) This bonito was used for infusing soups, and we might consider this a precursor to *katsuobushi* , the bonito flakes used in making dashi today. This bonito was dashi today. This bonito was likely treated with salt and dried until hard.

(2) Where does *kunkan* come from?

Is *kunkan* an indigenous technique of Japan? According to the most prevailing theory, the technique comes from Maldives, an island country in the Indian Ocean 7,000 km away from Japan. A Moroccan travel writer Ibn Baṭṭūṭa, who visited Maldives in 1343, reported that the country exported *katsuobushi* (*katsuo* was locally called rainbow trout) to India, Ceylon (Sri Lanka), China, Yaman (Yemen), and Malacca Sultanate (a sultanate that used to be located near Malaysia). Ryukyu Kingdom was trading with Malacca Sultanate. The theory suggests that the *kunkan* technique was brought to Japan via Ryukyu. [5]
Others argue that there is little relevance, claiming that many other places on the route were rich in *katsuo* and that there is no evidence *katsuobushi* was made in the country. Yet another theory suggests that production of *katsuobushi* began in the two countries independently of each other. I believe doing *kunkan* is meant for hygiene and pest control when trying to reproduce *katsuo* (dried) and *nikatsuo*. [6]

(3) *Katsuobushi* culture that flourished in the Edo period

The base of present *katsuobushi* production process was established during the 270 years (1603-1867) of the Edo period. By the late Muromachi period, *katsuo arabushi* made by fire drying, the predecessor of the *baikan* technique, was considered to exist. [5] In the early Edo period (*1), *katsuo arabushi* made by *baikan* began to be sold in the quantity as much as the business was profitable. This seems to be likely considering the year of establishment of Ninben (1699, the early Edo period) when it was already trading *katsuobushi*. *Shokoku*

Katsuobushi Banzukehyo (national *katsuobushi* raking list)[5] published in the late Edo period (Figure 1) shows Ise and Shima famous for *Kumanobushi* as referees. Reason for this may be that their *katsuobushi* was well-regarded at the beginning of the Edo period. Seishu (Isenokuni) was also a referee. It was chosen probably to give authority to the list as Ise Jingu shrine was there.

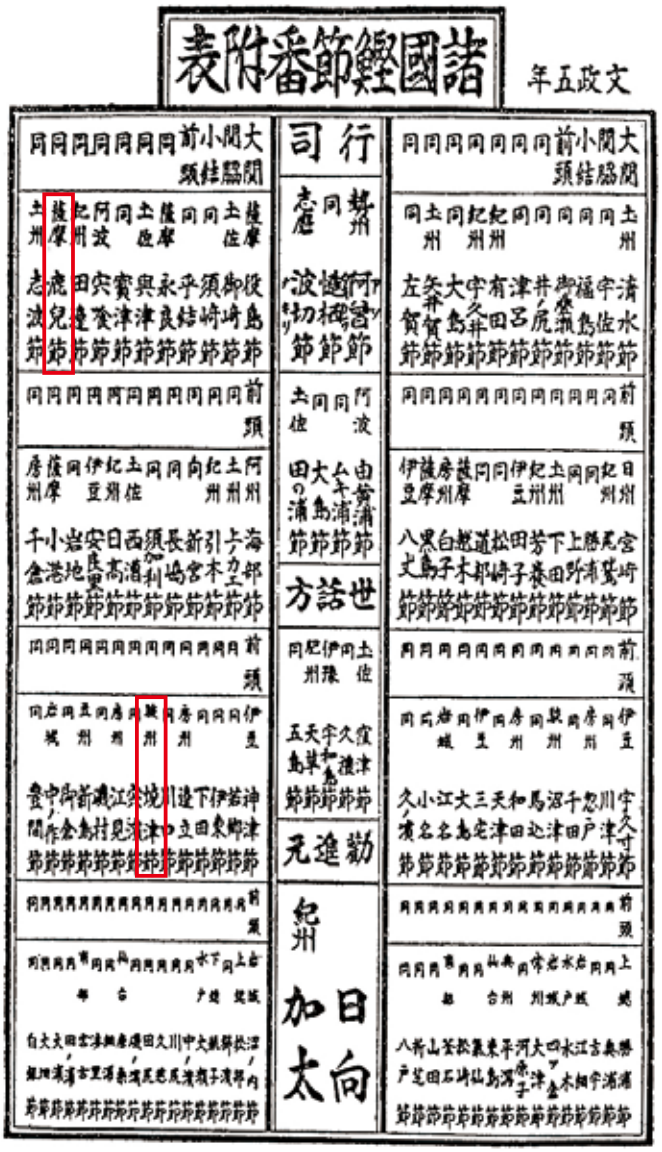


Figure 1. ***Shokoku Katsuobushi Banzukehyo*** **in Bunsei 5 (1822)**

- *Tosabushi* that used to dominate the top ranks is now produced by only one company in the Usa district.
- At present it is produced in Yaizu (Shizuoka), Makurazaki (Kagoshima), and Yamagawa (Kagoshima). These three regions alone produce more than 90% of the national production.

During the early to mid Edo period (*1), improved *arabushi* was developed in Tosa (Kochi). The surface of *arabushi* was scraped to make *hadakabushi*. It was then coated with mold once and thoroughly sun-dried. In the late Edo period (*1), Tosa no Yoichi, a *katsuobushi* artisan from Innan, Kishu (present Wakayama), introduced the production method of improved *Tosabushi* to Chikura in present Minamiboso and Arari in Nishiizu. Before the improvement, *Isebushi* was not simmered (*shajuku*) and thus it had to be coated with mold many times.
Tosa no Yoichi taught *shajuku* and scraping methods, and improved *Izubushi* was born. It was made in the same process as present *katsuo honkarebushi*: repeating *shajuku*, *baikan*, scraping, and several cycles of mold coating and sun-drying.

(*1) The Edo period (266 years) is divided into three with every five shoguns. Early (108 years): the first shogun (Tokugawa Ieyasu) to the 5th (Tsunayoshi), mid (77 years): the 6th (Ienobu) to the 10th (Ieharu), and late (81 years): the 11th (Ienari) to the 15th (Yoshinobu).

(4) How did the *katsuobushi dashi* culture in east and *kombu dashi* culture in west evolve?

Several factors have influenced the difference in *dashi* culture between the Western and Eastern Japan.

- *Kombu* seaweed and *katsuo* differ in habitat and fishing area. *Kombu* grows only in Hokkaido, Aomori and Iwate. *Katsuo* is found and caught along the Japan Current from Okinawa in the south to Miyagi in the north, or to the coast of Iwate depending on the flow of the Japan Current.
- There were many dangerous passages on the eastern route for the navigation technology of the time. Most skippers were reluctant to go directly to Edo and *kombu* was normally transported on a safer westbound route to Osaka. **Figure 2** shows the western route and the eastern route developed by Zuiken Kawamura in the early Edo period. The route for transporting *kombu* from Hokkaido was called Kombu Road. [7]
- The shipping wholesalers operating *kitamaebune* (northern bound ships) were initially running transport business. They later developed into trading firms. They bought *kombu* in Hokkaido and carried to Osaka via the Seto Inland Sea while selling in Toyama and Tsuruga where *kombu* was sold for high prices. This business made the *kitamaebune* shipping wholesalers immensely rich. *Kombu* supply was concentrated on more lucrative Western Japan.
- *Kombu dashi* is commonly used for *shojin ryori* (Japan's Buddhist cuisine), vegetarian diet as part of religious training (*2). The number of temples per population is large in Western Japan. That helped *kombu dashi* spread into the daily life of common people through religious events. Wealth was concentrated in the hands of temples and they could use expensive *kombu*.

(*2) *Kombu* is not produced in China and thus it is not used for original *shojin ryori*. Temples strictly following the *shojin ryori* rules introduced from China do not use *kombu* for their *shojin ryori*.

- *Kombu* wholesalers in Osaka paid tax to the shogunate and obtained the exclusive selling right to prevent the entry of newcomers.
- *Kombu* wholesalers in Edo traded *kombu* coming via Osaka and accordingly they were too expensive for commoners to readily afford.
- Edo was a city of *samurai* society. *Katsuo* was very popular in *samurai* society partly because its sound was similar to words auspicious for *samurai*, such as katsu-o meaning a winning man.

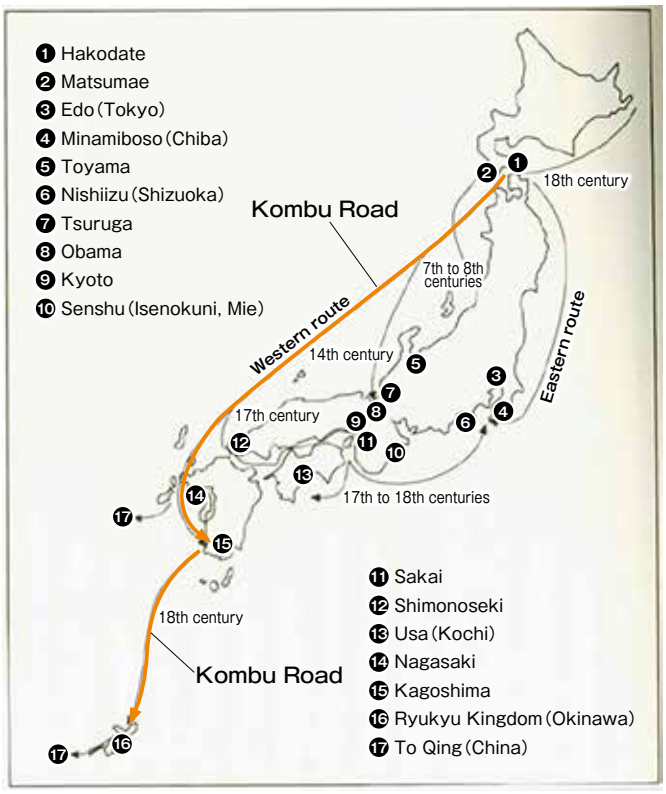


Figure 2. Western route, eastern route, and kombu road (source: *Shitte Okitai Washoku no Bunka* edited by Yo-Ichiro Sato, Benseisha Publishing (2022), with several modifications) [7]

- Although *kombu* should be exported to Qing China via Dejima in Nagasaki, Satsuma Han (domain) exported as herbal medicine via Bonotsu Port and imported herbs from which Chinese medicine was made. Some point out that the profits gained in this way funded the overthrow of the shogunate. [8]
- This illegal trade was later found out by the shogunate, which led to a major incident known as *Karamono-kuzure* (collapse of import from China). Merchant ships fleeing from Bonotsu to nearby Makurazaki were used as *katsuo* fishing boats and Makurazaki grew into a major landing port of *katsuo*. [5] [8]

Table 1 shows the top 15 prefectures in the number of temples per 100,000 people. Among them, 12 prefectures belong to Western Japan. The table also lists the *kombu* purchase quantity and amount in the capital of each prefecture. The number in parentheses is the rank among 52 cities surveyed.
Unlike *katsuobushi*, types of preferred *kombu* vary from region to region and prices vary with the type. If including the capitals with purchase quantity and amount above national average, the table indicates that the proportion of temples in Western prefectures correlates with either *kombu* purchase quantity or amount or both.

2. How *katsuo honkarebushi* is made from *katsuo*

Figure 3 shows the production process of *katsuo honkarebushi*. This production process is the result of the predecessors' efforts and wisdom on how to improve the shelf life and flavor while reducing moisture in *katsuo*.

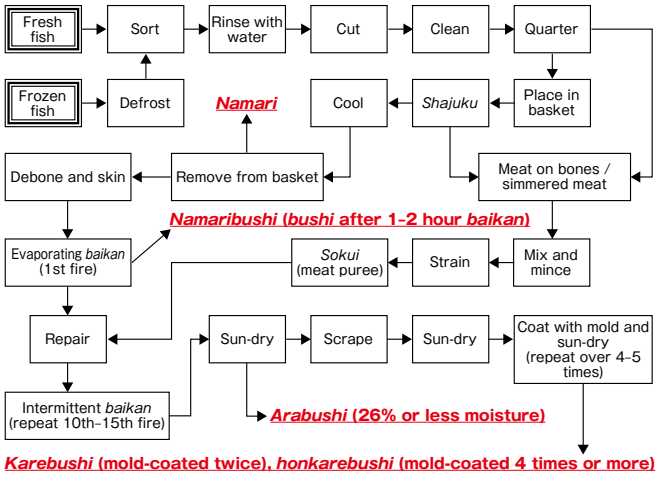


Figure 3. From *katsuo* to *katsuo honkarebushi*

Table 1. Number of temples per 100,000 people and *kombu* purchase quantity and amount by prefecture

Temple (organization/corporation)				Kombu		
Ranking	Prefecture	Total	per 100,000 people	City	Purchase quantity	Purchase amount
	National average	76,634	61.3	National average	214	798
1	Shimane	1,292	237.7	Matsue	335 (4)	962 (12)
2	Shiga	3,204	227.3	Otsu	232 (16)	1,170 (5)
3	Fukui	1,672	222.1	Fukui	320 (6)	1,478 (2)
4	Yamanashi	1,484	185.1	Kofu	154 (40)	578 (46)
5	Wakayama	1,585	175.5	Wakayama	113 (52)	650 (39)
6	Toyama	1,521	149.7	Toyama	330 (5)	1,663 (1)
7	Yamagata	1,477	141.9	Yamagata	420 (3)	1,222 (4)
8	Nara	1,803	138.1	Nara	172 (34)	890 (7)
9	Mie	2,347	134.7	Tsu	217 (22)	629 (42)
10	Saga	1,069	133.5	Saga	150 (43)	670 (7)
11	Niigata	2,755	128.0	Niigata	296 (9)	783 (25)
12	Ishikawa	1,352	120.9	Kanazawa	232 (17)	984 (10)
13	Kyoto	3,051	119.6	Kyoto	167 (37)	1,014 (9)
14	Oita	1,236	111.7	Oita	227 (20)	739 (31)
15	Yamaguchi	1,418	108.0	Yamaguchi	147 (45)	678 (36)

Note: Sakata in Yamagata, Niigata and Teradomari in Niigata, Akamagaseki (Shimonoseki) and Mitajiri in Yamaguchi were main ports of call of *kitamaebune*.

Photo 1 shows *katsuo* fillets (for *honbushi*) and finished *katsuo honkarebushi*. It takes about four to six months to make *katsuo honkarebushi* when 4.5-kg raw *katsuo* is used.

Photo 1. Comparison of raw *katsuo* fillets and *honkarebushi*

Changes in weight yield
Katsuo: 100%
Portion used: 75%
Namaribushi: 50%
Arabushi: 22%
Honkarebushi:15%

Katsuo: weight of approx. 6.0 kg with 70% moisture

Katsuo arabushi
Weight: approx. 1,300g/4 pieces
Moisture: approx. 24%

Katsuo honkarebushi
Weight: approx. 900g/4 pieces
Moisture: approx. 15%

Figure 4. Yield changes from *katsuo* to *katsuo honkarebushi*

Figure 4 shows changes in weight of raw *katsuo* cut into fillets ➡ *namari* ➡ *arabushi* ➡ *honkarebushi*. Yield in proportion to raw *katsuo* is reduced from 1/5 of *arabushi* to 1/6 of *honkarebushi*. In other words, a price rise in raw fish by 100 yen per kg equals a rise of 500 yen in *arabushi* and 600 yen in *honkarebushi*.

(1) After *katsuo* is filleted, *shajuku* is performed. The *shajuku* temperature needs adjustment according to the freshness and size of *katsuo*. When 4.5 kg or heavier *katsuo* is quartered (fillets for *honbushi*), they are placed into water at approx. 80°C, the temperature is raised to around 90°C, and the fillets are boiled for 90 minutes. *Shiagebushi*, which is *namari* made by *shajuku* and cooled, will be sold in the form of *bushi* (fillet) after skinning (partly leaving skin near the tail) and deboning. *Namaribushi* is *namari* subjected to *baikan* for two to three hours.

(2) Early stages (1st to 3rd fire) of *baikan* (*3) involve drying using high-temperature smoke and hot air. *Baikan* is repeated continuously till the 5th to 6th fire. After that, *baikan* is performed not everyday but at intervals while the surface moisture of *bushi* fillets is checked. This is called intermittent *baikan*. When the moisture content is reduced to 26% or less, the *katsuo arabushi* is complete.

(3) The surface of *katsuo arabushi* is covered with smoke components from *baikan*. Removing this surface layer by scraping with a grinder or a special knife and sun-drying once again result in *katsuo hadakabushi*. This scraping process ensures growth of beneficial *katsuobushi* mold on the surface.

(4) A suspension of purely cultured beneficial *katsuobushi* mold is applied to *katsuo hadakabushi*. The *hadakabushi* is then placed in a mold coating chamber with temperature and humidity kept constant. This starts the fermentation process in which the moisture is reduced and the flavor is improved with the help of important microorganisms.

(5) After the first mold coating, the *bushi* will be covered with well grown beneficial mold, then sun-dried for a day. This is the first mold-coated *bushi*.

(6) The first mold-coated *bushi* is placed in the mold coating chamber again to grow the beneficial mold. This time, a mold suspension is not applied. The *bushi* with mold grown again is called the second mold-coated *bushi*. When the first khaki mold begins to turn brownish, the second mold coating is completed. The *bushi* is taken out from the mold coating chamber and sun-dried for a day. This completes the *katsuo karebushi*.

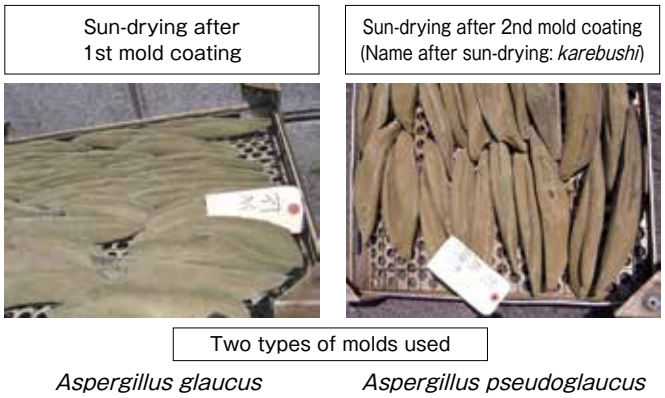


Photo 2. Changes in color tone from the first mold coating to the second mold coating

(7) After the second mold coating finishes, the step (6) is repeated. Sun-dried *bushi* is now called the third mold-coated *bushi* and, after that, the fourth mold-coated *bushi*. After the fourth, we call *bushi* as *katsuo honkarebushi* at Ninben. *Katsuo honkarebushi* is not specified in detail by the Japanese Agricultural Standards (JAS). Individual companies use their own standards.

(*3) *Baikan* (smoke-drying)

- Day 1 of *baikan* is called the 1st fire (or evaporating *baikan*) and Day 2 the 2nd fire. When a Yaizu-style dryer is used, *baikan* is performed till 11th or 12th fire for total duration of approx. 80 hours. In a *kyuzokko* (drying tower for mass production), *baikan* is performed to 12th or 14th fire and the whole *baikan* process takes about 100 hours. A high fat content in *katsuo* slows moisture reduction and increases the *baikan* duration.
- Smoker fuels used for *baikan* are logs of well-dried oak, Japanese oak, konara oak, sawtooth oak, and other broadleaved trees. In the past, trees in local mountains were used, which gave distinct characteristics of each production area. Today, similar logs are used all over the country. The characteristics of *bushi* mainly come from difference of *baikan* facilities used.
- *Baikan* is a very important process in *katsuobushi* production. Not only it imparts smoky flavor to *katsuobushi* but also it is proven to provide diversified effects such as antioxidation, rot resistance at an early stage, and production of pyrazines by high temperature.

Photo 3. Various *baikan* systems

Tebiyama-style *baikan* method

Namari fillets are placed in steamers and put over a fire bed with burning logs to expose the fillets directly to smoke and hot air. This *baikan* method is considered to have been used since the early Meiji period (1868-1912). It is still used in several regions including Nishiizu and Ise.

Takinaya-style *baikan* tower

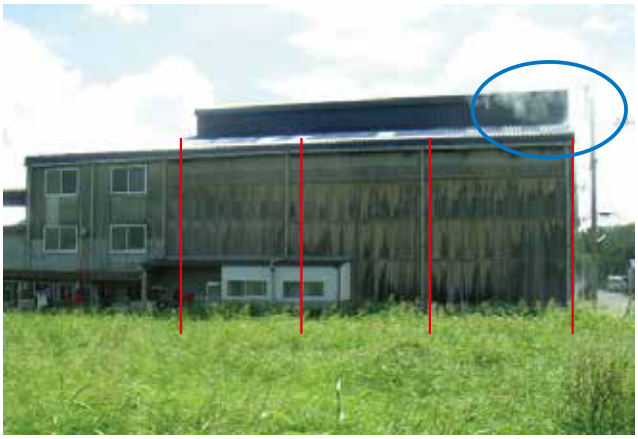
The tower is divided into five layers: *baikan* is started with fillets placed in the first layer, then they are moved away from fire to the second, then to the third layers, and finally to the fifth layer for adjustment.

Yaizu-style dryer (medium-scale *baikan* system)

The fire bed is in the place marked with a red circle. Smoke and heat are sent by a fan into the *baikan* chamber with a blue circle mark.

***Kyuzokko* (drying tower for mass production)**

Exterior of *kyuzokko*



It is a three-story building with a basement. Logs are burned in the basement and *baikan* is performed on the first, second, or third floor depending on how much *bushi* is dried. The *kyuzzoko* shown in the photo is divided into three blocks (red lines) to adjust production. The rightmost block is in operation (blue circle mark).

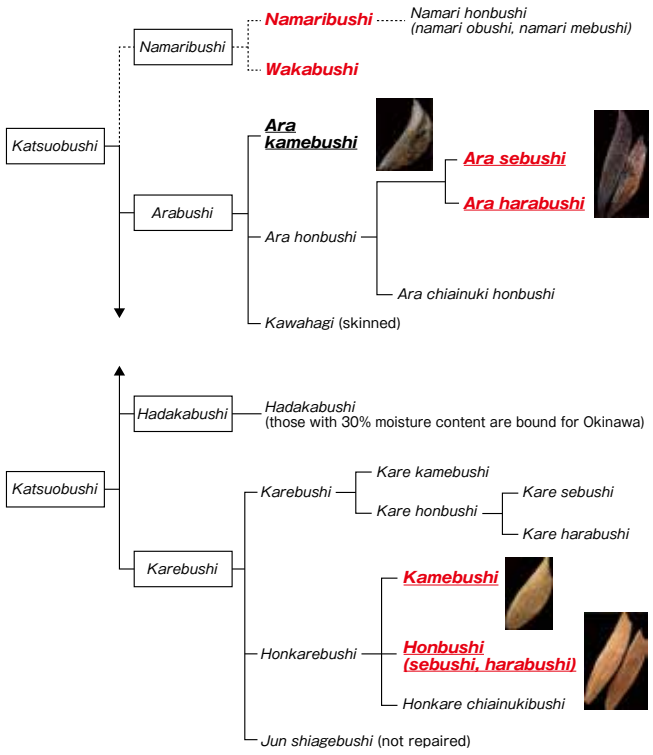


Figure 5. Types of *katsuobushi*

- *Katsuobushi* at different steps of production process is sold as different products.
- These products are named in accordance with the rule of Japan Katsuobushi Association. Naming rule: Fish name (*katsuo* or *maguro*) + process + form.
  For example, if fish is *katsuo*, process is *ara*, and form is *honbushi*, it is called *katsuo arahonbushi*.
  Note: As is often the case with traditional food industries, people often follow the conventional business practices and it is difficult to collate *bushi*-related statistical figures.

Table 2. Comparison of nutritional facts between *katsuo* caught in spring and autumn

Food and description			*Katsuo* Caught in spring, raw	*Katsuo* Caught in autumn, raw	*Katsuobushi*
Energy		kcal	108	150	332
Water		g	72.2	67.3	15.2
Protein		g	25.8	25.0	77.1
Lipid		g	0.5	6.2	2.9
Carbohydrate		g	0.1	0.2	0.8
Ash		g	1.4	1.3	4.0
Minerals	Sodium	mg	43	38	130
	Potassium	mg	430	380	940
	Calcium	mg	11	8	28
	Magnesium	mg	42	38	70
	Phosphorus	mg	280	260	790
	Iron	mg	1.9	1.9	5.5
	Zinc	mg	0.8	0.9	2.8
	Copper	mg	0.11	0.10	0.27
Vitamins	A Retinol	μg	5	20	Tr
	A Carotene	μg	0	0	0
	A RAE	μg	5	20	Tr
	D	μg	4	9	6
	E	mg	0.3	0.10	1.8
	K	μg	(0)	(0)	(0)
	B1	mg	0.13	0.10	0.55
	B2	mg	0.17	0.16	0.35
	Niacin	mg	19.0	18.0	45.0
	B6	mg	0.76	0.76	0.53
	B12	μg	8.4	8.6	15.0
	Folate	μg	6	4	11
	Pantothenic acid	mg	0.70	0.61	0.82
	C	mg	Tr	Tr	(0)
Fatty acids	Saturated	g	0.12	1.50	0.62
	Monounsaturated	g	0.06	1.33	0.33
	Polyunsaturated	g	0.19	1.84	0.81
Cholesterol		mg	60	58	180
Salt equivalents		g	0.1	0.1	0.3
Remarks			Aka: *Hatsugatsuo*	Aka: *Modorigatsuo*	

3. Science of *katsuobushi*

(1) Fat content in *katsuo*

Katsuobushi is made only from *katsuo*. Not just any *katsuo* is suitable. If unsuitable *katsuo* is used, even if the production process shown in Figure 3 is implemented under perfect conditions, you won't get good quality *katsuobushi*. It is first necessary to select *katsuo* suitable for *katsuobushi*.

Except for premium products, most *katsuobushi* is made from frozen *katsuo* caught by overseas purse seiners in southern waters. FADs (fish aggregating devices) leveraging the behavior of *katsuo* and tuna ensure efficient fishing. However, there is a ban period for fishing using FADs for resource management of tuna. In 2026, FADs are prohibited for 1.5 months in the exclusive economic zone (EEZ) and for 2.5 months on the high seas. During these periods, overseas purse seiners target fatty *katsuo* in the deep sea and therefore fatty *katsuo* is mainly used for *katsuobushi*.

Not all *katsuo* caught in the seas around Japan is suitable as an ingredient of *katsuobushi*.

Table 2 shows the nutritional facts of *hatsugatsuo* and *modorigatsuo*, taken from the Standard Table of Food Composition in Japan (8th revised edition). [9]

Fat content greatly influences *katsuobushi* quality. If *katsuobushi* has a high fat content, a phenomenon called *shirata* may occur. *Katsuobushi* with *shirata* is more likely to crumble when grated into flakes and the flakes are also likely to break into powder. In addition, a report reveals that *shirata* deteriorates the taste, makes *dashi* cloudy, and reduces the free amino acid content and inosinic acid content. Raw *katsuo* caught in autumn (*modorigatsuo*) has a high fat content of more than 6% and very likely to cause *shirata*. *Modorigatsuo* is delectable as sashimi and *tataki* (seared sashimi) but not fit for *katsuobushi*.

In contrast, *katsuo* caught in spring (*hatsugatsuo*) has only a 0.5% fat content and suits *katsuobushi*. [11, 12]

Table 3. Relationship between occurrence of *shirata* and fat content in the surface

Fat content in the surface (%)	Incidence of *shirata*
3.6	±
4.7	±
4.1	±
5.0	±
5.9	+
6.5	+
6.9	++
9.3	++
12.6	++

Shirata

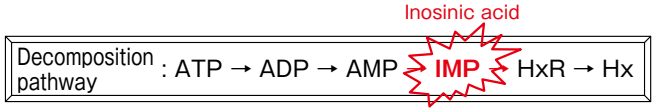
± : Rarely seen.
\+ : Seen a little in the surface.
++ : Seen 1/2 to 1/3 of the whole.

Fat in *katsuo* is mostly contained as subcutaneous fat and orbital fat and in stomach and intestines. [10] When making *katsuobushi*, the head and innards are removed but subcutaneous fat cannot be removed completely even by *shajuku*. Residual fat makes moisture in *namari* hard to remove during *baikan* and hinders drying.
When selecting *katsuobushi* in a store, check the skin left near the tail. Avoid *katsuobushi* with deeply wrinkled skin and choose ones with no or slight wrinkles.

(2) Changes in inosinic acid quantity

The main *umami* component of *katsuobushi* is inosinic acid. Production of inosinic acid is explained based on **Figure 6**.
ATP (adenosine triphosphate), which is energy currency used to move muscles, is decomposed rapidly by nuclease to ADP (adenosine diphosphate), then to AMP (adenosine monophosphate), and to IMP (inosine monophosphate or inosinic acid). Since the decomposition slows down after IMP, IMP accumulates in muscles. Over time, it is further broken down to inosine and then to hypoxanthine. Among these nucleic acid related substances, it is only IMP that has *umami*. Very fresh *katsuo* that has just been caught won't have much of its distinct *umami*. To make *katsuobushi* rich in inosinic acid, *katsuo* needs to be simmered (*shajuku*) when the accumulation of inosinic acid peaks. This inactivates nuclease and retains inosinic acid. It resembles the aging of tuna and beef.

Figure 6. Decomposition pathway of nucleic acid related substances



Therefore, *katsuo* for *katsuobushi* is selected, based on the operating area and characteristics of the fishing boat to place a bid for; the fattiness, freshness and size of sample *katsuo*; the flow of the Japan Current and water temperature distribution; information on future deep-sea fishing, fishing regulations (Western and Central Pacific Fisheries Commission (*4)), and price trends.

(*4) Western and Central Pacific Fisheries Commission (WCPFC)
WCPFC is a regional fishery management organization for highly migratory fish stocks in Pacific Ocean west of 150°W including Japan in the northern hemisphere and west of 130°W, east of 141°E, and north of 60°S in the southern hemisphere. The fish stocks include bluefin tuna, bigeye tuna, skipjack tuna, yellowfin tuna, albacore, marlin, and marine sharks.

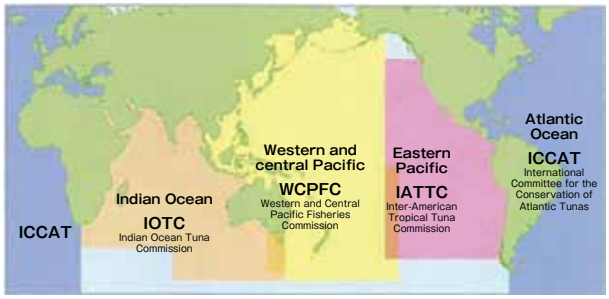


Figure 7. Regional fishery management organization for highly migratory fish stocks in each sea area

4. Science of *dashi*

Dashi omission test is a study to identify important components consisting of *katsuobushi dashi*. First, possible components of *katsuo honkarebushi dashi* (nitrogen-containing components: free amino acids, nucleic acid related substances (e.g., IMP), organic bases, and peptides, and nitrogen-free components: organic acids and sugars) are identified and analyzed. Using the resulting data, synthetic *katsuobushi* dashi is prepared. Each component is omitted from each group and the differences in taste indicate the key components.
The *dashi* omission test shows that *katsuobushi dashi* is made up of the following nine key components.

- Histidine, glutamic acid, inosinic acid, lactic acid, creatinine, inosine, hypoxanthine, sodium, and chlorine

The following table shows how the tastes changed when each of the components was omitted. Each taste is marked with + when slightly enhanced and ++ when greatly enhanced for each component. They are also marked − when slightly reduced and −− when greatly reduced. The representative *umami* of *katsuobushi dashi* is said to be inosinic acid. But eight other components are also playing an important supporting role. [14]

Table 4. Components necessary for the taste of ***katsuobushi dashi***

Omitted components (mg／100ml)

1.	Tau	1	10	Val	0.5	16.	AMP	1.6
2.	Gly	0.8		Ile	0.3	17.	IMP	14.8
3.	Ala	1		Phe	0.5	18.	Ino	5.8
4.	His	62.3		Trp	0.1		Hx	0.4
5.	Asp	0.06		Orn	0.2	19.	Sugars	
6.	Glu	0.7		Arg	0.2	20.	Lactate	106.7
7.	Leu	0.8	11.	Ans	39.1	21.	Other organic acids	
8.	Lys	0.9	12.	Car	3.3			
9.	Met	0.5	13.	TMA	0.6	22.	Na	13.6
	thr	0.3		TMO	0.2	23.	K	21.5
	Ser	0.4	14.	Cre	15.9	24.	Mg	17.0
	Pro	0.2	15.	Crn	35.9	25.	P04	17.0
						26.	Cl	50.0

Taste changes

	Sweetness	Acidity	Saltiness	*Umami*	Persistence	Richness	Smoothness
Glu	+			++	+	+	+
Na			+			+	
Cl				+	+	+	+
IMP			+	++	++	++	+
Lactic acid		++					
His		++		+			
Crn				−			− −
Ino+Hx							
Lys							
Car							
K				+		+	

+:Slightly enhanced ++:Greatly enhanced −:Slightly reduced − −:Greatly reduced

As to the salt reduction effect of *katsuobushi* discussed below, the studies for selection of relevant components were started based on this omission test result.

5. Science of *katsuobushi dashi* making

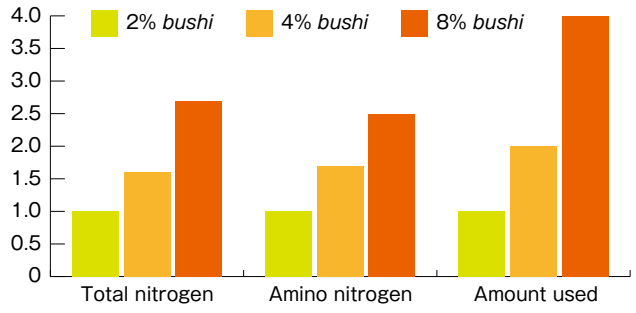
Soft water is used to make *katsuobushi dashi* just like *kombu dashi*. Tap water contains chlorine for hygienic reasons. It is recommended that tap water should be dechlorinated with a home water purifier.
It is also recommended that soft water should be used. Hard water does not suit the aroma and taste of *dashi*.

When making *dashi* using *katsuobushi*, the extraction efficiency of *dashi* components varies with the amount and thickness (*5) of flakes used. The extraction efficiencies were obtained by examining the extracted components (total nitrogen and amino nitrogen) in *dashi*.

(*5) JAS specifies that thin flakes are 0.2 mm or less and thick flakes are over 0.2 mm in thickness.

(1) Ratio of *katsuobushi* flakes to water for highly efficient *dashi* making

Refer to Figure 8. The test was performed using 2% (base), 4% (twofold) and 8% (fourfold) *katsuobushi* flakes. The result indicates that total nitrogen and amino nitrogen didn't increase twofold or fourfold. This means *dashi* components remain in the used flakes. You should make second *dashi*. [16]



Extraction conditions: Heat 1 min, leave to stand 3 min, and filter.

Figure 8. Changes in extraction efficiency by difference in amount of *katsuobushi* flakes

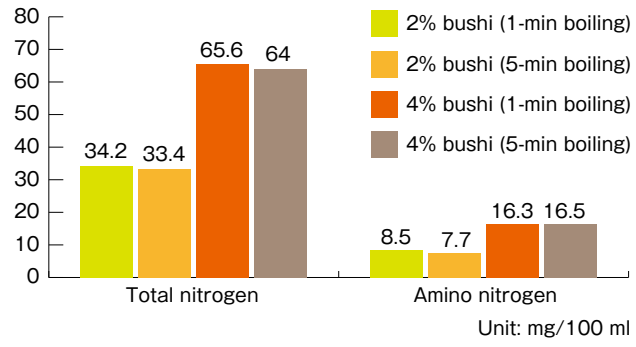


Figure 9. Difference in extraction efficiency by difference in *dashi* making time

There is no difference in extraction of *dashi* components whether between 1 min and 5 min. 1 min is long enough to make *dashi*. [16]

Dashi yield varies between summer and winter and with pan size and type of stove (gas and induction). Therefore, we recommend the following methods to make quality *dashi* with high extraction efficiency, constant yield, and little cloudiness.

(1) Making the first *dashi*
- When water in the pan comes to boil, turn off the heat.
- Put thin flakes of *katsuobushi* at 3% of water and leave it to stand for one or two minutes.
- Spread gauze or paper towel on a sieve, strain flakes, and leave to stand for one minute.
- Do not squeeze the flakes.

(2) Making the second *dashi*
- Place the used flakes in a pan and add water half that used in making the first *dashi*.
- After it begins to boil, simmer on low heat for three to five minutes, and turn off the heat.
- Add 1/6 of new flakes used for the first *dashi* and leave to stand for one or two minutes.
- Spread gauze or paper towel on a sieve and strain flakes.
- Lightly squeeze the flakes.

* Adding new flakes is called *oigatsuo* in culinary science. This enhances the aroma of the second *dashi*.

(3) *Dashi* making time by flake thickness
Sometimes, strong *dashi* is needed, for instance, to make dipping sauce for *soba* noodles. Using thin flakes, the required quantity may be so large that flakes may not be well soaked in water. In that case, use thick flakes.
Thick flakes are generally 0.8 to 1.0 mm in thickness. They are four to five times as thick as common thin flakes. To ensure high extraction efficiency, it is necessary to add flakes while the water is boiling, adjust the heat, and keep it gently boiling for 40 to 50 minutes. [17]

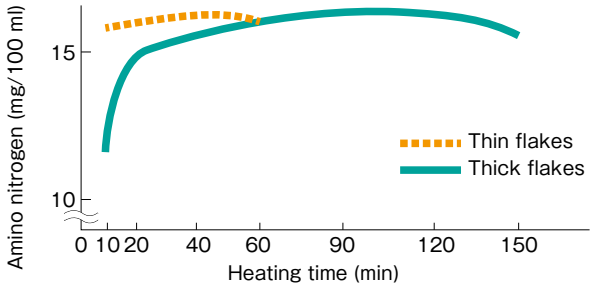


Figure 10. Changes in amino nitrogen in common thick flakes

Note: The thickness varies from manufacturer to manufacturer. Ask the manufacturer.

- Because it takes longer to make *dashi* using thick flakes, amino acid reacts with sugar in *dashi* and the Maillard reaction produces browning substance (melanoidin). Some experts believe that this substance imparts richness. The same effect may occur to *soba* sauce base in *dotanpo* (*6) passed down from generation to generation for tens of years at a long-established *soba* restaurant.

(*6) *Dotanpo* is a ceramic container used to heat *soba* dipping sauce in a bain-marie. In the past, most *dotanpo* was made of unglazed ceramics. [18]

6. Science of *katsuobushi* flakes

The expiration period (best-by) of *katsuobushi* is two years when kept in a package and one year after the package is opened. But, after processed into flakes, the

aroma fades and off-odor components are produced rapidly in several days. This is caused by many reactions such as:

- Production of off-odor components including linear aldehydes due to lipid oxidation and degradation
- Dissipation of beneficial volatile components (*7)
- Reduction of hydrogen sulfide by oxidation and change to sulfur [15]

(*7) ***Katsuobushi*** **is said to have more than 400 types of aroma components. Many beneficial aroma components evaporate at low boiling points.** [13]

<Storage of *katsuobushi* flakes after package is opened>
After the package is opened, it is ideal to use it up. However, some flakes come in large bags.

- Remove the air inside the bag as much as possible. (If it is a zipper bag, remove the air in the bag and close the zipper.)
- Avoid intense light and store it in a fridge. Do not store in a freezer. [15]

7. Intriguing power of *katsuobushi* and *katsuobushi dashi*

Food serves various functions. Primarily it provides nutritional components essential to life, then pleases the palate, and lastly adjusts the functions of the body. This section mainly discusses the functions to please the palate.

(1) Adhesion of bitterness by *katsuobushi* flakes

- The bitter substances of bitter melon are triterpenoids. *Katsuobushi* flakes adhere these triterpenoids. In stomach acids, triterpenoids are released from the flakes. [19]

(2) Antioxidant effect of *katsuobushi dashi* in cooking

- When *katsuo dashi* was used for simmered sardines, the fishy smell was reduced. The DPPH radical scavenging activity of the broth increased and the TBA value of sardines fell. [20]

(3) Reduction in acidity and acidic smell by addition of *katsuo dashi*

- The acidity of lactic acid and the acidic smell of acetic acid decreased in proportion to the amount of *katsuo dashi* added. Acetic acids derived from aroma components in a dressing and mayonnaise were reduced by 71% and 83%, respectively. [21]

(4) Improvement to salty taste preference and enhancement of saltiness by *katsuo dashi* [22][23]

- The aroma of *katsuo dashi* has an effect of increasing preference for a low-salt saline solution.
- *Umami* of *katsuo dashi* has an effect of increasing preference for a low-salt diet.
- Histidine contained in *katsuo dashi* has an effect of enhancing salty taste.

These three effects of salty taste improvement indicate that using *katsuo dashi* may help extend health life expectancy in Japan, where the population is rapidly aging.

8. Closing

There are many research reports about physiological functions of *katsuobushi dashi*. They are published in the literature [24] below.

<Expected effects on human body>

- Alleviate fatigue (mental and physical).
- Control high blood pressure.
- Slow gastric emptying, which helps you feel full longer.
- Facilitate stomach movement.
- Stimulate salivary secretion.
- Alleviate hunger and increase satiety.
- Increase brain activation.
- Suppress fat intake and calorie intake.

<Expected effects on the state of mind and emotional behavior>

- Improve mood and emotional state (especially feeling of fatigue).
- Decrease aggressive behavior.
- Reduce depressive-like behavior.
- Reduce anxiety-like behavior.

We hope the research will progress further.

References

(1) Japan Tourism Agency, Ministry of Land, Infrastructure, Transport and Tourism. *Honichi Gaikokujin Shohidoko Chosa* (survey on consumption trends of inbound tourists).
(2) Yoko Okubo. *Edo no Chomiryo* (seasonings of Edo), Journal of the Japan Society of Cookery Science, Vol.147, No.4, 233-235 (2014).
(3) Akira Matsui. *Kokogaku kara Mita Katsuoryo* (*katsuo* fishing from an archaeological perspective), *Nihonjin wa naze katsuo wo tabete kitanoka* (why have Japanese been eating skipjack tuna), Ajinomoto Foundation for Dietary Culture (2005).
(4) Shigeji Ogura. *Kodai no Hyakkazensho "Engishiki" no Tabunya Kyodokenkyu - Chukan hokoku* (Multidisciplinary Collaborative Research on the Ancient Encyclopedia "*Engishiki*" - Interim report), *Bulletin of the National Museum of Japanese History* (2019)
(5) Akira Miyashita. *Katsuobushi Jokan* (*katsuobushi* volume 1), Japan Katsuobushi Association (1989).
Akira Miyashita. *Mono to Ningen no Bunkashi 97 Katsuobushi* (cultural history of things and humans, 97 *katsuobushi*), Hosei University Press (2000).
(6) Isao Kumakura and Toru Fushiki (supervised), Shinya Fuke (edited). *Dashi towa Nanika* (what is *dashi*), I & K Corporation (2014).
(7) Satoshi Ishikawa. Chapter 6 *Washoku to Sakana* (Japanese cuisine and fish), *Shitte Okitai Washoku no Bunka* (washoku culture you should know) edited by Yo-ichiro Sato, Benseisha Publishing (2022). Original is taken from the Japan Kombu Association website.
(8) Takashi Okui. *Kombu to Nihonjin* (kelp and Japanese), Nikkei Business Publications (2012).
(9) Council for Science and Technology, Ministry of Education, Culture, Sports, Science and Technology. Resources research subcommittee report: 2022 Standard Table of Food Composition in Japan (8th revised edition).
(10) Mayuko Morita et al. *Nihon Taiheiyogan no Noborikatsuo oyobi Kudarikatsuo no Kakubui ni okeru Shishitsu Henka* (changes in fat by part of northbound and southbound skipjack tuna along Japan's pacific coast), *Nippon Suisan Gakkaishi*, vol.69, No.6 (2003).
(11) Chiaki Koizumi. *Katsuobushi no Shirata ni kansuru Kenkyu II* (research on *shirata of katsuobushi* II), *Nippon Suisan Gakkaishi*, vol.27, No.2 (1961).
(12) Fumio Takenaga et al. *Shirata Katsuobushi to Seijo na Katsuobushi no Soshishitsu no Hikaku* (comparison in total fat between *katsuobushi* with *shirata* and normal *katsuobushi*), *Journal of the Japanese Society for Food Science and Technology*, Vol.38, No.4 (1991).
(13) "*Oishisa no Kagaku*" planning committee. *Katsuodashi ga Yamitsuki ni naru Riyu* (reason for getting addicted to *katsuo dashi*), *Oishisa no Kagaku Series* No.4 (2012).
(14) Shinya Fuke. *Katsuo Ekisu, Dashi no Seibun to Teimisei* (skipjack tuna extract, *dashi* components and taste quality), *Nihonjin wa naze katsuo wo tabete kitanoka*, Ajinomoto Foundation for Dietary Culture (2005).
(15) Hirokazu Kawaguchi. *Katsuobushi Fureba no Seisei to Rekka* (generation and degradation of *katsuobushi* flavor), *Nihonjin wa naze katsuo wo tabete kitanoka*, Ajinomoto Foundation for Dietary Culture (2005).
(16) Fujiko Yoshimatsu. *Nidashijiru no Kenkyu* (*Dai Ippo*) (research of dashi: 1st report), *Journal of home economics of Japan*, Vol.5, pp. 359-361.
(17) Fujiko Yoshimatsu. *Dashibiki no Kagaku* (science of *dashi* making), *Bessatsu Shokudo Soba Udon* (separate volume: restaurants, *soba* and *udon* noodles), Vo.7 (1980).
(18) Shigeru Niijima. *Soba no Jiten* (dictionary of *soba*), Shibatashoten (1999).
(19) Kenji Maebashi et al. *Kezuribushi ni yoru Goya no Nigami Jokyokoka* (*katsuobushi* flakes' effect of eliminating bitterness from bitter melon), *Journal of the Japanese Society for Food Science and Technology*, Vol.55, No.4 (2008).
(20) Aki Nashimoto et al. *Chori ni okeru Katsuobushi dashi no Kosankakoka* (antioxidant effect of *katsuobushi dashi* in cooking), *Journal of the Japan Society of Cookery Science*, Vol.41, No.3 (2008).
(21) Jun Yamada et al. *Katsuobushi dashi no Tenka ni yoru Sanmi, Sanshu Yokuseikoka* (reduction in acidity and acidic smell by addition of *katsuo dashi*), *Journal of the Japan Society of Cookery Science*, Vol.44, No.2 (2011).
(22) Mariko Manabe. *Washoku Tokuyu no Kaori ga Enmi ni Oyobosu Eikyo - Dashi to Shoyu* (effects of characteristic aroma of washoku on salty taste - *dashi* and soy sauce), *Journal of the Japan Soy Sauce Technology Center*, Vol.46, No.4 (2020).
(23) Mariko Manabe. *Katsuodashi no Enmi Zokyokoka ni Kiyosuru Teimi Busshitsu* (taste substances contributing to the *katsuo dashi's* effect of enhancing salty taste), *Journal of the Japan Society of Cookery Science*, Vol.51, No.3, 173-179 (2018).
(24) Takashi Kondo et al. Mechanism of Suppressive Effects of Dried Bonito Dashi on Aggressive Behaviors in Mice, *Journal of the Brewing Society of Japan*, Vol.112, No.12 (2017).