Traditional Japanese Foods and the Mystery of Fermentation

Takeo Koizumi
Professor, Tokyo University of Agriculture

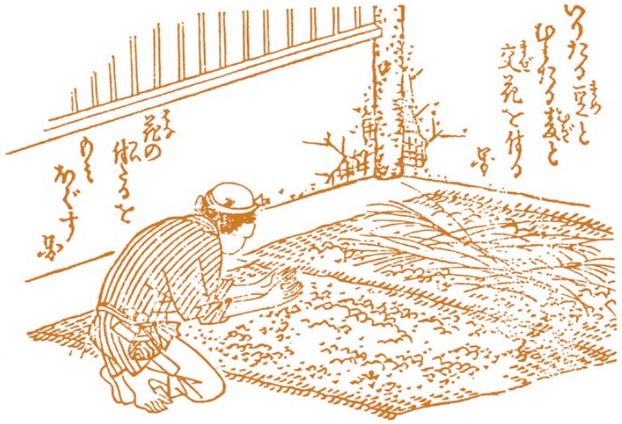
Takeo Koizumi
Professor, Tokyo University of Agriculture
Takeo Koizumi was born in 1943 to a sake-brewing family in Fukushima Prefecture. He graduated in 1966 from the Department of Agriculture at the Tokyo University of Agriculture. His area specialties include the brewing and fermentation sciences. Publications include: *Sake no Hanashi* (The Story of Sake); *Hai no Bunkashi* (A Cultural Record of Ash); *Kishoku, Chinshoku* (Strange Foods, Rare Foods); *Hakko* (Fermentation); *Nihonshu Renaissance* (A Renaissance of Japanese Sake), and others.

One of the characteristics of traditional Japanese food is the presence of a wide variety of so-called fermented foods–foods produced using organisms so small they cannot be seen by the naked eye. There are so many fermented foods that it would be impossible to list them all, but some common ones still eaten today include soy sauce, *miso* (soybeen paste), vinegar, sake, *mirin* (sweet sake for cooking), *tsukemono* (pickles), *natto* (fermented soy beans), *narezushi* (a type of sushi), *katsuobushi* (dried bonito flakes) and *kusaya* (dried mackerel).

What is remarkable is not only the large variety of these types of food, but also the wide range within each type. Let's consider soy sauce, for example. Historically, Japanese were not satisfied with the grain-based variety of soy sauce that is used widely today; available alternatives included the formerly popular fish-, meat- and vegetable-based soy sauces. The soybeans, barley and rice used in *miso* were substituted, in earlier times, with a variety of other grains, with nuts from the Japanese oak, and with horse chestnuts. In the Nansei Islands, residents even used nuts from the Japanese sago palm (*cycas revoluta*).

The same pattern applies to Japanese sake, which has rice as its main ingredient. The Heian era (794-1185) code *Engishiki* reveals the surprising fact that sake was classified into 13 categories, based on such factors as the degree to which its rice was pounded and the amount of *koji* (malted rice) used. Well-known sake varieties included *goshu* and *reishu*, the highest-grade sakes; *zakkyushu*, which was issued to public officials as part of their salary; *shiroki* and *kuroki*, which were used in Shinto ceremonies; and *aesake,* which was used in cooking. For more detailed information about these topics, interested readers may refer to my publications *Hakko* and *Nihonshu no Renaissance* (both available from Chuko Shinsho).

Many traditional Japanese foods are created through the mysterious, dynamic process of fermentation. I would like to introduce several phenomena thought to have some connection to the earliest days of fermented foods. In Shiga Prefecture there is a town called Ritto. During the Nara period (710-784), its citizens built a shrine with the rather unusual name of Kin-jinja (literally, bacilli shrine). Shrines bearing the name *kin* (bacilli) are indeed unusual, and my research so far has failed to turn up



This illustration shows the production of *shoyu koji*. The writings in the illustration say,"An illustration which depicts how to mix roasted beans and steamed wheat," and "An illustration depicting the flower, the seed starter of *koji* mold (*tane koji*) being strewn on the mixture." From the *Koueki Kokusankou*, an agricultural book of the Edo era (1603-1867).

any others. After looking up the meaning for the *kin* character in several well-known historical dictionaries published in China and Japan, I found only one meaning listed; namely, "mushroom." But oddly enough, although the character for *kin* is a general term for mushrooms, the Kin-jinja shrine in Ritto actually has no connection to mushrooms. In fact, the item enshrined on its altar is a loach *narezushi*. Loach *narezushi* is a preserved food made by pickling raw loach in salt. The fish is then transferred to a tub and placed between layers of cooked rice for further pickling. The fermentation process takes half a year and uses mostly lactic-acid bacilli.

Little is known about why the Kin-jinja shrine is dedicated to *narezushi*, but in the province of Omi (present-day Shiga Pref.) that surrounds Lake Biwa, *narezushi* is made using carp, *amenouo*, fresh water trout, eel and loach. Preserved *narezushi* has been highly valued since ancient times as both a nourishing food and a source of protein. Originally, there was little room for error in the production of *narezushi*, since the process relied on the fermentation of such precious ingredients as rice, fish and salt. Loach *narezushi* was probably placed on the altar and worshipped in an appeal to the gods to ensure that the food turned out successfully.

It is certainly interesting that, by presumed coincidence, the Kin-jinja shrine would be dedicated to a food that is produced using fermented bacilli. Indeed, it is impossible to consider this puzzling tale–which to some might suggest that the early Japanese knew of the existence of (lactic-acid) bacilli–without appreciating the depth of skill required to master the fermentation process, which requires one to comprehend the application of microscopic organisms. Whatever the practical reality, the story is a fascinating one.

At some time during the later Heian (794-1185) or early Muromachi period (1336-1573), an event occurred that had critical consequences for the production of fermented foods: the discovery of *tane koji* (a seed starter of *koji* mold). This mold is produced as follows. First, *koji* mold (*Aspergillus oryzae*) is bred on steamed rice. Over time, the *koji* mold produces numerous spores. Next, the rice and spores are separated using silk sieves, and large quantities of the spores are collected and dried for preservation. Spores can then be strewn over steamed rice or boiled soybeans to produce large quantities of soybean *koji* or rice *koji* whenever required.

The *tane koji* process made it possible to mass-produce sake, soy sauce and *miso* for the first time. Behind the discovery of *tane koji* lay a surprisingly imaginative insight: the key to its invention was the discovery of what were called *inakoji* or *inadama*, which are dark green balls that attach themselves to the heads of rice in the fields. They are actually made up of two different microorganisms: *koji* mold (*Aspergillus oryzae*) and a pathogenic bacterium called *Usutilaginoidea virens*. Even today it is sometimes possible to find these balls stuck to the heads of rice plants.

Long ago, a certain wise individual collected these balls from a rice field, mixed them with a large quantity of ash left over from the burning of some plants, and left the mix for a while. After a year or so had passed, the mixture was strewn over boiled rice and covered with straw matting to keep it warm. This process allowed only

koji kin to breed over the rice, and the result was a healthy crop of *tane koji*. The *Usutilaginoidea* was destroyed owing to the strong anti-bacterial properties of the ash, and was never able to breed. Interestingly enough, not only is ash unable to kill *tane koji*, it is actually used as a growth medium. It is for this reason that even today, factories use ash as part of the production process for *tane koji*.

It is amazing to think that nearly one thousand years ago, *tane koji* makers were clever enough to cultivate pure *tane koji* using ash, then market it as a starter under the same name to soy-sauce manufacturers, *miso* manufacturers and sake brewers. Nowhere else in the world at this time could you find anyone able to isolate and purify microorganisms, let alone market them as an individual commodity. One can only marvel at the extraordinary depth of knowledge of the Japanese people at that time. Judging by the fact that those involved were no doubt aware of the "anti-bacterial powers" of ash when they used it to isolate and purify *tane koji*, it might be accurate to consider the Japanese as the first people to purify and isolate microorganisms. If so, we would also have to come to the rather romantic conclusion that the Japanese were the first to recognize the existence of microorganisms. (Today, it is widely accepted that microorganisms were discovered by the Dutch scientist Anton van Leeuwenhoek, who in 1673 invented the first microscope and confirmed the existence of microorganisms.)

For centuries, the ideas and examples that I have outlined thus far have served as the basis for application of the knowledge of microorganisms in Japan. These are the concepts which, together with this country's geography and climate, led to the leading role of fermentation in Japanese food culture. Because the Japanese have such a long history and tradition of skillfully utilizing molds (filamentous fungi), ferment bacilli and yeast, they now rank among the most experienced in fermentation technology.

Lack of space prevents me from describing in detail many other wondrous examples concerning traditional Japanese fermented foods. Instead, I will focus on one particularly astonishing fermented food invented by the Japanese–an item without parallel anywhere in the world. The story embodies Japan's original approach to fermented foods, and also illustrates these points: the willingness of the Japanese to eat anything available; the dignity that comes from living from the ocean's bounty; and the commitment to minimize waste that is at the heart of Japanese cuisine.

Among the traditional fermented foods produced in Mikawa, Ono, Kanaiwa and other locations around the city of Kanazawa, as well as in the Noto region in Ishikawa Prefecture, there is a dish made from *fugu* (blowfish) ovaries pickled in *nukamiso* (rice-bran paste). There is something distinctly grotesque in using a thing so deadly poisonous as the basis for a food dish, and something uncanny in utilizing the fermentation properties of a microorganism to detoxify that poison–and creating a food that is safe to eat.

The pickling of *fugu* flesh in rice-bran paste began at the end of the Edo period (1603-1867); the dish itself became a local delicacy at the start of the Meiji era (1867-1911). The main species used in the making of this dish were deadly poisonous varieties of *fugu* such as *mafugu* (*torafugu*), *gomafugu, sabafugu* and *akamefugu*. At first the rice-bran paste pickling process was only used on the nonpoisonous flesh of the *fugu* to produce a preserved food, which was a popular success. However, at a certain time of the year the female *fugu* develops an extremely large ovary. A thin membrane surrounds the ovary, but the ovary's interior is a dazzling bright yellow; it had strong appeal as the potential base for a new food dish. Tempting yes, but life is precious. In the case of *torafugu*, the ovary alone sometimes weighs over a kilogram and contains enough poison to kill some 20 people.

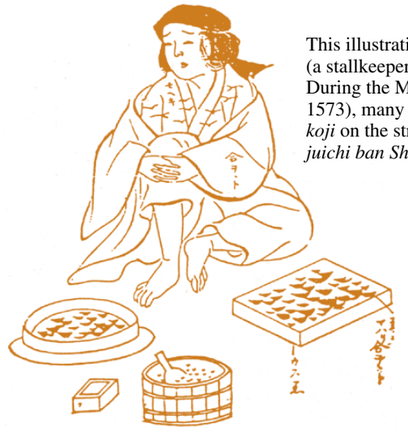
Yet throwing the ovary away seemed such a waste, and someone hit upon the idea of pickling it in rice-bran paste. At the time, *nukamiso* was an indispensable part of the daily diet, so the idea of pickling *fugu* ovary in something so close to hand probably came quite easily. Considerable time and expertise were required to detoxify the *fugu* ovary completely. No doubt the initial process was to remove the *fugu* ovary from the *nukamiso* every now and then and test it, a process that presumably produced some casualties. After a long process of trial and error, however, this strange food was finally perfected.

Similar approaches to food cannot be found outside Japan. And considering that pickled *fugu* ovary was developed by applying knowledge gained through daily living, it remains an almost overwhelming accomplishment. Indeed, this esoteric fermented food could only have been produced in Japan, where pickles are an essential part of the diet, and by the Japanese, who survive on the ocean's bounty.

Today, the production of pickled *fugu* ovary begins with the selection of the ovary. Instead of throwing away ovaries left over when *fugu* flesh is pickled in *nukamiso* or *mirin*, these remaining ovaries are set aside. One company alone cannot collect sufficient ovaries, so more are purchased from other *fugu* processors. Nowadays, efforts are made to obtain the best ovaries available, and they are also brought in from processing companies in Hakata and Shimonoseki. Next, the ovaries are placed in fresh water to remove any surface dirt, and the unwanted stringy tubes attached to the ovary's chorion are removed along with other extraneous materials. The ovaries are then placed in a tub and a 30% mix of salt is added. The resulting mixture is set aside for between six months and a year.

The ovaries are then removed and pickled in *nukamiso* that contains a small amount of rice *koji* and some salted sardine or mackerel broth. They remain there, fermenting beneath a stone weight, for over two years before finally being shipped out or pickled in sake lees for another month. Compared to other pickled fish products, *fugu* ovaries have a higher salt content and are fermented for a longer time. The traditional explanation is that this approach removes the poison and indeed, the highly poisonous tetrodotoxin found in *fugu* before pickling has completely disappeared from the end product. Not only have there been no reported cases of death after eating this dish, it is nowadays sold as a regional delicacy at local souvenir stores in Kanazawa, as well as at pickle stores and specialty shops.

The actual mechanism for removing the poison is understood as follows: First, some of the poison is drawn out of the *fugu* during the salt pickling process. Most of the remaining poison is then broken down and neutralized by lactic-acid bacilli, yeast and other microorganisms during the *nukamiso* pickling process. The lactic-acid bacilli are smaller and more active than yeast, and are therefore more effective in penetrating the *fugu* ovaries through the membranes, once these are broken down as a result of the salt pickling process. These bacilli break down the tetrodotoxin into carbon dioxide, water and nitrogen and then consume the nitrogen, thus rendering the toxin inert.



This illustration shows a *koji-uri* (a stallkeeper who sold *koji*). During the Muromachi era (1336-1573), many such *koji-uri* sold *koji* on the street. From the *Shichi-juichi ban Shokunin Uta Awase*.

Finally, let's consider what it's like to eat *fugu* ovaries pickled in rice-bran paste. The aroma is quite strong and similar to that generally associated with Japanese pickles, but contains extremely pastoral notes with a nostalgic quality. The ovary's outside membrane is a dull light gray, but the ovary's actual interior is a vivid yellow, crammed with tiny eggs. This savory dish has a complex and rich sour taste, and a character that makes it hard to believe that it was once highly poisonous. It accompanies Japanese sake well, but according to an acquaintance of mine in Kanazawa, the best way to eat it is as *ochazuke*. This dish is prepared by filling a deep bowl about two-thirds full with hot rice, then adding a desired amount of crumbled *fugu* ovary over the rice. One then adds some grated *wasabi* (Japanese horseradish), sliced *mitsuba* (Japanese parsley) leaves, and a dash of powdered *sansho* (Japanese pepper). Finally, hot Japanese green tea is poured over the top. *Ochazuke* should be gently scooped into the mouth while the diner meditates on calming his or her fluttering heart. The flavor surpasses that of most other kinds of *ochazuke*–it arguably ranks among the top gourmet-style dishes in its category.

Let us not forget that this rather extreme Japanese culinary pastime of removing the toxin from the ovary of a poisonous blowfish in order to render it edible would not be possible were it not for the great respect the Japanese have for food; i.e., that they are loath to waste anything. There exists an endless curiosity that encourages them to try any food–along with a deep commitment to turn a rarity into a delicacy. And above all, there exists the enduring inspiration of Japan's unique, centuries-old tradition and technology of fermentation.