



Bringing Japanese fermentation technologies to the world

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The author, born in 1969, accomplished credits for a doctoral program (second term) at the Division of Agriculture, Tokyo University of Agriculture Graduate School, and received a PhD in agricultural chemistry. He is engaged in the study of factors that enrich eating habits such as seasonings, tastiness, and tastes. He continuously takes a scientific approach to fermentation and tastes, and more specifically, foodstuff changes caused by fermentation, fermented seasonings, analysis of tastes, and the mechanism of the sense of taste. His works include the following three publications written in Japanese: "Koji's Magical Power to Create Umami/旨みを醸し出す麹のふしぎな料理力," (co-authored, Tokyo University of Agriculture Shuppankai), "Proposal to Use Koji Amazake instead of Sugar/砂糖の代わりに糴甘酒を使うという提案," (co-authored, Ascom Inc.) and "Immunity-Conscious Life with only Cloudy Vinegar/にがり酢だけの免疫生活", (Seishun Shuppanya).

How is "oishisa (tastiness)" produced?

I study specifically fermented foods in the field of fermentation science, and place the most emphasis on their tastes or oishisa. Naturally, foods must be tasty. Appreciating oishisa or joy brought by oishisa makes everyone on earth happy. In line with this idea, I focus especially on seasonings, and more specifically, on fermented seasonings that take advantage of fermentation to make foods tasty. By approaching oishisa from the mechanism by which humans sense tastes and component changes that occur in foods, we are coming to understand how oishisa is produced.

For example, some studies revealed that lysozyme, a protein in egg whites, tastes sweet. Lysozyme is an immunoprotein contained in egg whites as well as in mammals' breast milk. It is also contained in cold medicines. How is the sweetness produced? It tastes sweet because the tongue sensor for sweetness is activated by the positive and negative charges on the surface of the lysozyme molecule. In other words, molecular structures are important for humans to feel the tastes of substances. Only molecules with certain structures present a taste. Interactions between molecules may prevent bitterness from being felt or bring out sweetness or umami. Foods are savored through a fairly complex mechanism, and an infinite number of tastes sensed through that mechanism can be produced. It may be possible to produce tastes beyond our imagination.

One taste component that has seen active research for a long time is peptides produced as a result of protein degradation. Peptides are not a main player in producing tastes, but have the role of producing a good taste. Of the 20 kinds of amino acids, different ones connect to make different peptide structures. Consequently, there are an infinite number of peptide structures with different types, numbers, and sequences of amino acids. Peptides with a certain

structure have been found to have an antioxidation effect, a hypotensive effect, or other functionalities. A slight difference in structure results in different physiological activity as well as different taste. These peptides are involved in the tastes of fermented foods containing lots of protein degradation products, and combinations of an infinite number of peptides varying in taste produce tasty fermented foods with specific complex umami.

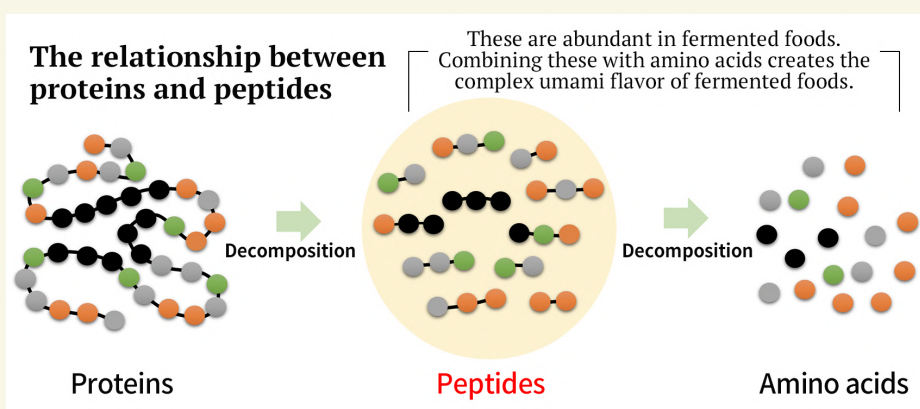
The same goes for components other than protein, such as starch. A microorganism's enzymes decompose components and separate a single molecule into an infinite number of smaller molecules, which produces not only a wider variety of tastes but also solid and thick umami. This is the wonder of fermentation. We have not yet found all of the specific molecules involved in fermentation, and elucidating these one by one is my goal, and is essential for making the depth of Japanese fermented foods known to the world.

"Koji" is the basis for fermentation in Japan

In 2013, washoku, traditional Japanese food culture, was registered as an Intangible Cultural Heritage by the UNESCO. Since then, Japanese fermentation culture and fermented foods have been attracting greater attention. One of these is shio-koji (*), which is easy to incorporate in the daily diet, and it has come into general

use as a popular seasoning. It is common knowledge in the field of zymology that enzyme-rich koji produces umami, but this opportunity seems to have given koji, which had previously been playing the behind-the-scene role in producing shoyu and miso, a good chance to come into the spotlight. "Tema-e-miso" is a Japanese idiom for self-praise. The term literally means "my own miso." As suggested by this word, miso had been made in every home since the Edo era. Japanese people of former days pickled vegetables in koji left over after the miso-making process. This means that the technology of shio-koji has existed since a very long time ago. Leftover koji is not discarded but reused with care. The wisdom of the Japanese can be seen in this practice.

Actually, shio-koji itself does not contain many umami components, but the results of analyses on its components revealed that its principal component is sweet, as with amazake. The salt in it prevents it from tasting sweet, but when it is used in cooking, appropriate saltiness is combined with sweetness to produce a good taste or umami. The enzymes in koji act on foodstuffs, producing umami and making them tasty. The power of koji brings out the tastes of foodstuffs. This can be said to be the greatest feature of Japanese fermented seasonings. From analyzing the effects of shio-koji, we were able to rediscover the fact that koji is the basis for Japanese fermented foods.



Japan has developed its own fermentation technologies that compare favorably with those outside Japan. The main feature is that various fermented foods are made by mainly using koji, and these fermented foods are used as seasonings. By using fermented seasonings made using koji, we can receive the benefits of fermentation from our daily diet. Koji is a pillar of the Japanese diet.



Shio-koji is a salty fermented seasoning made by mixing approximately 10% salt, rice koji, and water to effect saccharification. It is generally a gruel-like or pasty seasoning, but may be in a powder or liquid state, which is not common. Rice koji is steamed rice in which *Aspergillus oryzae* has been cultivated, and contains various digestive enzymes produced by the mold when it grows. Especially, rice koji contains rich amounts of amylolytic enzymes, and adding water to rice koji and heating the mixture produce highly concentrated glucose since the rice starch is digested in the process. Shio-koji contains koji enzymes even after it is put on the market, and the enzymes bring about changes to foodstuffs when it is used in cooking.

Invisible fermentation and visible fermentation

Japanese people have used its own food technologies to bring out umami and sweetness even from less flavorful foodstuffs, and harmonize seasonings with foodstuffs in a fine balance. We have been continuously producing Japanese foods with delicate tastes by combining different kinds of kitchen knife skills with different cooking methods such as boiling, steaming, stewing, and grilling and using enzymes in foodstuffs to bring out flavors from them. We combine cooking technologies that take advantage of the tastes of foods with enzymes in koji to bring out complex umami specific to Japanese foods. In the West, on the other hand, scientific and functional cooking methods are popular. Western people generally extract good components from foodstuffs, and add single taste substances such as salt and sugar to add flavors.

Japanese traditional fermentation processes use microorganisms in a very complex and delicate manner. The technology for manipulating invisible

microorganisms is almost mysterious. This is considered to be based on our food culture of cereals, vegetables, and fishery products, and on the ancient Chinese idea of Hishio (salted food) or the technology of pickling these foodstuffs with a large amount of salt and preserving them in a hot and humid environment. The idea is that pickling foodstuffs with salt allows only useful microorganisms to cause natural fermentation without rotting them.

On the other hand, fermentation in the West is more simple and more rational. For example, the fermentation process must be clear as seen in the process of making yogurt by adding lactic acid bacteria to milk, or the process of making wine by adding yeast to grape juice. Western people may feel anxious about the hygienic safety of keeping foods at ordinary temperatures to grow unidentified microorganisms.

Since ancient times, Japan, without knowing the existence of microorganisms, has cultivated fermentation technologies through experience and trial and error. In modern days, the power of science allows us to unlock the secrets of fermentation to some extent. For example, in the process of making koji, how to steam rice, how to mix and warm koji, and all other methods for handling koji are scientifically significant. Sophisticated fermentation technologies produce fermented foods that are of high quality and offer excellent health benefits. Elucidating this complex mechanism is an interesting challenge for me as a researcher, and I am sure that taking on this challenge will help to spread safer fermentation techniques across the world. Eventually, the mechanism will be elucidated at the molecular level, which will help to reveal what effects fermentation has on the human body and find more specific means for using fermentation for our health.

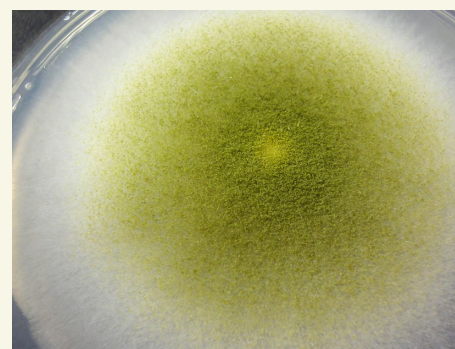
Spreading Koji technologies across the world

To spread the wonder of Japanese fermentation across the world, it is necessary not only to raise awareness to existing fermented foods, but also to spread and let people around the world know Japanese-style fermentation technologies. To do this, we first need to understand regional cultures, such as what foods are eaten by a particular ethnic group in that country or region,

and what lifestyle is led there. Our taste and flavor preferences are developed after birth, and we come to know our own likes and dislikes about foods in the course of living. What tastes people like is quite different depending on the region they were born in and their race. We combine foods eaten in a region with microorganisms to produce fermented foods unique to that region. Koji is a technology that helps this process. By turning a foodstuff into koji by a fermentation technology using *Aspergillus oryzae*, whatever the foodstuff is, a fermented product with a unique flavor can be made. This fermented product or koji can be combined with another microorganism to promote further fermentation.

Recently, there have been an increasing number of studies on Japanese fermented foods outside Japan, but it seems that what has already been known in Japan since quite a long time ago is being reported by many of these studies. This may be because information in this field has been shared in the country but has not been disseminated adequately to the world.

However, the concept that “Japanese fermentation is invisible” is about to reach a turning point. This is because significant advances in technologies for analyzing genes and components are enabling us to scientifically elucidate the phenomenon of fermentation, the characteristics of microorganisms, etc. For example, mold is intrinsically poisonous, but the analysis results demonstrated that *Aspergillus oryzae*, a mold that has been domesticated by the Japanese over a long period of time, is not poisonous but safe. If evidence can be obtained, what effects fermentation has can be explained from medical, sitological, and bromatological perspectives, and the idea that food is medicine could be demonstrated by the health benefits of



A giant colony of *Aspergillus oryzae* cultured in a petri dish. Research has played a role in promoting visualization of the Japanese fermentation technology.

traditional fermented foods.

The future created through coexistence with microorganisms

I think that fermentation technologies could be used to address a food crisis we may encounter in the future, or protein insufficiency. Amino acids, which are materials for protein, can be mass-produced using microorganisms. A typical mass-

production method of this kind is glutamic acid fermentation, a technology invented by the Japanese and is currently used around the world. Some microorganisms can mass-produce protein. There is a good chance that microorganisms with new capabilities may be found in the future since there are an infinite number of microorganisms on Earth still unknown to human beings, and even traditional fermented foods may contain some

unknown microorganisms. By making effective use of the fermenting power of microorganisms, it may be possible to find a clue to solving food crises in the future. Microorganisms have existed long before the birth of human beings. The idea that the true coexistence of microorganisms and human beings may significantly change the future once again makes me excited about how great the secrets of fermentation are.

Column

Learn from wisdom given by fermented foods

There are countless fermented foods in various regions around Japan. Unique foods have been produced by taking advantage of the climates of various regions, the variety of local foodstuffs, and the wisdom of people living there that has been handed down to date. Of the unique fermented foods not covered in this booklet, the editorial supervisor introduces three of them here:

Daitokuji (Daitoku-ji Temple) natto / Kyoto Prefecture



Hishio that retains the original form of miso and shoyu

This is natto introduced to the Daitoku-ji Temple in Kyoto Prefecture, which provides the origin of its name. It is also called “shio kara natto” or “tera natto.” This natto is not stringy like itohiki natto, and is made by allowing *Aspergillus oryzae* rather than *Bacillus subtilis* natto to ferment the soybeans. This natto contains a high concentration of salt because soybeans are pickled with a high concentration of salt. As fermentation by halotolerant lactic acid bacteria also takes place in this process, it has a strong salty, umami, and sour taste. This natto is quite similar to Chinese touchi, is like the original form of miso, and is made by methods similar to those for making soybean miso or tamari shoyu. It is eaten as a snack served with tea as it is or used as a seasoning in cooking.

Kabura zushi (turnip sushi) / Ishikawa Prefecture, Toyama Prefecture



Pickled fish, a lacto-fermented food that is rare in the world

This is a traditional fermented food made in Ishikawa Prefecture and Toyama Prefecture. It is made by sandwiching a slice of a yellowtail between turnip slices and allowing the sandwich to ferment. It is called sushi, but does not use vinegared rice and is a kind of sliced pickles rather than sushi. It is like sushi where the turnip slices substitute for rice. Since salted yellowtail slices are pickled together with turnip slices and rice koji, lactic acid fermentation takes place, which gives the dish a sour taste. In this sense, Kabura zushi can be said to be a kind of fermented sushi called “nare-zushi.” It does not have a distinct flavor like traditional nare-zushi, as it is easy to eat and not aggressively flavored.

Miki / Kagoshima Prefecture



Drink with a wild flavor made by lactic acid fermentation

This is a traditional fermented drink popular in the Amami Islands. It is made by using different ingredients, such as rice powder, sweet potato, rice koji, and barley koji, depending on the island. Miki made from barley koji and rice powder has a subtly sour taste like fresh amazake. Miki is made by adding water to ingredients, kneading the mixture, and leaving it to sit at room temperature to allow lactic acid bacteria to carry out fermentation. This produces a sour taste unique to lactic acid

Let's incorporate fermented foods into our daily diets.

The more you know about fermented foods, the more you recognize their depth, but there is no point if you do not savor them in your daily diet. They can also be expected to offer health benefits, and it would be a waste not to eat them. In the end, let us introduce a fermented food that can be made easily and consumed on a daily basis.

A drink called oxymel can be made by mixing vinegar and honey, then diluting the mixture with water. It is a drink with a slightly sour and subtly sweet taste and can be drunk easily on a daily basis to obtain the health benefits of vinegar. During the summer, you may want to dilute it with carbonated water. It is said that oxymel is a drink recommended by Hippocrates, the father of medicine (around 400 B.C.).

In ancient Greece, vinegar was widely used for medicinal purposes, and it is believed that Hippocrates prescribed vinegar as treatment for most diseases including common colds and coughs.

Books written about Hippocrates carry a recipe for making oxymel, saying that oxymel could be made by boiling honey, adding the same quantity of vinegar, and diluting the mixture to 20 times as much water.

In modern days, studies have been made on which components of vinegar are beneficial to health, and it has been reported that acetic acid, which is the main component of vinegar, has a blood pressure lowering effect, a visceral fat reduction effect, and other functionalities. And recently it is suggested that acetic acid bacteria used in vinegar production has the effect of regulating the immune system due to a component in its cell wall.

Fermented foods are the product of the accumulated wisdom and experience of our ancestors, which have been handed down to modern day. We have been enjoying the wonderful world of fermented foods and have been entrusted with the mission to pass it on to future generations.

Information about related websites

Our Regional Cuisines



A website that introduces regional cuisines that use fermented foods introduced in this booklet, and provides information about various regions in which the culture of eating fermented foods has taken root was created. The website can be viewed in five languages (English, simplified Chinese, traditional Chinese, Spanish, and Thai). Please visit these websites.

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