



An Introduction to

Japanese fermented foods

Introduction

Washoku or Japanese traditional food culture was registered as a UNESCO Intangible Heritage in December 2013, and will mark the 10th anniversary of its registration in 2023.

The Ministry of Agriculture, Forestry and Fisheries of Japan set the export targets of 2 trillion yen by 2025 and 5 trillion yen by 2030 for agricultural, forestry, fishery and food products in the **Basic Plan for Food, Agriculture and Rural Areas** (approved by the Cabinet on March 31, 2020) and the **Basic Policy on Economic and Fiscal Management and Reform 2020** and the **Follow-up on the Growth Strategy** (approved by the Cabinet on July 17, 2020), and compiled measures to achieve these targets in the form of the **Strategy to Realize Export Expansion of Agricultural, Forestry, Fishery and Food Products** in December 2020.

Looking at overseas trends, the number of overseas Japanese food restaurants increased from approx. 55,000 restaurants in 2013 to approx. 159,000 restaurants in 2021, which shows that Japanese foods are remarkably high in demand and popularity. It is considered that the reason for this is that Japanese foods have diverse dimensions such as their tastiness, history, and healthiness, and Japanese agricultural, forestry, and fishery products can be differentiated from those made in other countries. As awareness about healthy diets is increasing around the world, there has been increasing demand for miso, soy sauce, natto and other fermented foods indispensable in Japanese foods in and outside Japan, which creates a need for detailed information on these fermented foods.

Under such circumstances, this booklet was compiled to help people understand Japanese fermentation culture by clearly explaining the basics, history, and culture of Japanese fermented foods and typical Japanese fermented foods from a variety of perspectives, and also explaining its differences from fermentation cultures outside Japan. We hope that this booklet will be read by more people and help to protect and hand down Japan's unique fermented food culture, enhance recognition of various Japanese food cultures, and expand exports of agricultural, forestry, fishery and food products made in Japan.

March 2023 Ministry of Agriculture, Forestry and Fisheries_Minister's Secretariat_New
Business and Food Industry Department Food Service Industry and Food Cultures
Division_Food Cultures Office

Information about [Traditional Foods in Japan]

This document was created as a content for the Traditional Foods in Japan, a website run by the Ministry of Agriculture, Forestry and Fisheries. In the Traditional Foods in Japan, Japanese traditional foods are divided into 17 categories to help readers to understand them easily. Information is transmitted through a database of the characteristics, histories and recipes of selected traditional foods from various regions as well as the regional backgrounds against which such foods were born. Visit this website, and you will want to learn and know about and eat Japanese traditional foods.



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1-1 What are fermented foods?

Bread, yogurt, miso soup, shoyu, natto, beer, wine, and sake are foods and alcoholic beverages indispensable to our daily diet. They are all fermented foods. Fermented foods are made from ingredients such as cereals and soybeans by microorganisms invisible to the naked eye, but what kind of phenomenon is fermentation, anyway? Here, the mechanism of fermentation, the difference between fermentation and rotting, and the tastiness and functionalities of fermented foods are explained in detail.



Fermentation and its mechanism

Fermented foods are foods produced using microorganisms such as molds, yeasts, and bacteria. Fermentation is a phenomenon in which the growth and activity of a microorganism in a food cause a change in the food components useful to humans. For example, alcohol and organic acid made from sugar, lactic acid made from sugar, and acetic acid made from alcohol are all products of fermentation.

Enzymes produced by microorganisms may cause changes in food components. This is also a kind of fermentation. Enzymes can decompose rice starch into sugar, and soy protein into amino acids, which are a component of the umami (savory) taste. However, fermentation does not always require the involvement of a microorganism. For example, an enzyme contained in a food or a food component may undergo a chemical reaction that produces a useful component change. This kind of change is called “aging,” which is also a kind of fermentation.

The miso, shoyu, bread, yogurt, wine, and sake that we usually consume are all foods produced by the action of some microorganism. For example, the aging of miso are proceeded by the action of enzymes produced by *Aspergillus oryzae*, a kind of mold. The taste of miso changes differently depending on the length of the aging period. Miso, shoyu, sake, and wine are available in various types, which is largely due to not only ingredients but also changing the aging period.

Fermentation and putrefaction

When a microorganism causes a change useful to humans, we call the

phenomenon “fermentation,” and when a microorganism causes a harmful change, we call the phenomenon “putrefaction.” Fermentation and putrefaction are the same phenomenon, and whether a phenomenon is fermentation or rot is decided by humans, based only on whether it is useful or not. If a harmful microorganism grows in a food, it emits an unpleasant odor or tastes bitter or strange. For this reason, we can avoid the intake of putrefied foods through the sense of taste or smell. The line between fermentation and rotting is drawn based on whether the change is favorable to us or whether it is safe, rather than what component or microorganism is involved in the phenomenon. Fermented foods have been handed down through the generations as regional traditions, and this long experience with these foods provides evidence that they pose no threats to our safety.

Why don’t fermented foods easily rot? In the world of microorganisms, there is a phenomenon called “antagonism.” It is a phenomenon in which when a certain microorganism becomes dominant in an environment, other microorganisms can no longer enter the environment. Fermented foods have a long shelf life

because this antagonism works to prevent putrefactive bacteria from entering the system.

It is believed that rice koji (*1) originated from an event where mold in the air adhered to steamed rice offered at household altars and grew, aided by the humid climate of Japan. In Western European and Central Asian regions, where dairy farming was popular and a milk-consuming culture existed, lactic acid bacteria naturally adhered to milk left to stand and resulted in lactic acid fermentation, producing yogurt and other dairy products with a good shelf life. Fermentation is closely associated with the climate of the region where it takes place. Which microorganism is likely to grow depends on the region, and humans have found the characteristics of microorganisms through experience and produced region-specific fermented foods. Fermented foods can be said to be processed foods produced by skillfully manipulating the technology of fermentation.

*1 Rice koji is steamed rice in which *Aspergillus oryzae* has been propagated, and is used to produce various fermented foods such as miso, soy sauce, and sake.

Relationship between microorganisms and fermented food

Ingredient	Microorganism	Fermented food
Wheat	→ Yeast	→ Bread
Fruit	→ Yeast	→ Wine
Milk	→ Lactic acid bacteria	→ Yogurt, cheese, butter
Rice	→ <i>Aspergillus oryzae</i> , Yeast	→ Rice wine, shochu, mirin
Soybeans, rice, barley	→ <i>Aspergillus oryzae</i>	→ Miso, soy sauce
Rice, fruit	→ Yeast, Acetic acid bacteria	→ Rice vinegar, vinegar

Why are fermented foods tasty?

People enjoy fermented foods for their taste and unique scent. Cereals, seafood, and many other ingredients in fermented foods are highly nutritious, but are less flavorful eaten plain. However, sake has a mellow and sweet taste or flavor. Soy sauce made from wheat and soybeans has strong umami and a rich flavor. Shio-koji (*2), when used in cooking, adds strong umami to foodstuffs and makes the nutrients easier to absorb. The process of fermentation decomposes the original components and makes them easier to digest and absorb. It also produces richly flavored components and adds to the tastiness of foodstuffs.

Rice and soybeans are rich in starch and protein, respectively, which actually have little taste. The reason that rice tastes a bit sweet is that the glucose constitutes starch has a sweet taste. The reason of good taste of protein-rich meat is that proteins are constituted of amino acids that have an umami taste.

The surface of the human tongue has organs called taste buds, by which we can sense tastes. Taste buds are a collection of many taste cells specialized in sensing tastes, and taste cells have five sensors to sense sweet, bitter, umami, sour, and salty tastes. The taste of a food depends on which sensor is stimulated by the food components. However, the taste sensors

can sense small molecules, but cannot sense large molecules such as starch and protein. The reason that we can taste strong umami from fermented foods is that the fermentation decomposes large molecules contained in ingredients to make it easier for them to stimulate the taste sensors.

Rich flavors are a sign of health benefits

Fermented foods are not only tasty but also highly nutritious. One of the health components produced by fermentation is peptides. Protein contained in fermented food ingredients is decomposed in the process of fermentation. Peptides are protein fragments produced by the enzymatic decomposition of a protein, and they have structures containing amino acid chains. Fermented products contain a variety of peptides with different amino acid sequences, and it has been known that the peptides exhibit various physiological activities depending on their structures.

For example, some peptides made from milk protein by lactic acid bacteria-derived proteases, which are proteolytic enzymes, function to regulate blood pressure, and are widely used in foods with a specific health use. Peptides with a similar function are also contained in soy sauce. These peptides are made from soy protein by an *Aspergillus oryzae*-derived enzyme. Oligosaccharides are made from starch

by an *Aspergillus oryzae*-derived enzyme. Some oligosaccharides provide nutrition for intestinal bacteria, and amazake (sweet fermented drink made of rice) and shio-koji, which contain oligosaccharides, can be expected to improve the intestinal environment. It is difficult to chemically determine whether a component beneficial to health was produced by fermentation, but flavor of the components produced in the process of fermentation can be considered as a sign suggesting that some health benefit was produced.

Many of the microorganisms involved in fermentation have proteolytic enzymes. *Aspergillus oryzae*, which is indispensable for producing Japanese fermented foods, has a particularly high proteolytic capacity. The results of genomic analyses of *Aspergillus oryzae* demonstrated that it has more than 100 types of proteolytic enzyme genes.

Fermented foods contain various health components produced by microorganisms. Advances in analytical technology have made it possible to found various functionalities of substances resulting from the decomposition or metabolism of food components during the process of microbial growth.

*2 Shio-koji is a fermented seasoning made by mixing rice koji with salt and water to promote saccharification and maturation. The enzyme of *Aspergillus oryzae* increases the umami of foodstuffs or makes them soft.

Column

Relationship between region, microorganisms, and fermented food

The origin of fermented foods depends on various condition, such as the climate and topological conditions of the region, what kind of food ingredients are produced locally.

For example, “soy sauce brewed in a wooden barrel” using traditional methods is a region-specific fermented food. The wooden barrels provide an environment easy for microorganisms to inhabit, and are used over a long period of time. As a result, microorganisms, such as lactic acid bacteria or yeast that produce the soy sauce flavor, suited to the environment of the region or brewery settle in the barrels. Such microorganisms act to produce the unique soy sauce flavor of that particular brewery.

It is said that soy sauce made by this method of using wooden barrels accounts for less than 1% of the entirety of soy sauce production these days as more efficient methods are preferred. However, the loss of wooden barrels means the loss of the diversity of soy sauce. Driven by a sense of crisis over the loss of the tradition, brewers in Shodo-shima Island in the Seto Inland Sea, where brewing using wooden barrels has traditionally been popular, are working to hand down the technology to the following generations by apprenticing themselves to a craftsman to learn how to produce and maintain

wooden barrels by themselves.

The diversity of fermented foods has been nurtured by the climate of individual regions and the environments in which they are produced, and will be handed down by the efforts of people engaged in the production of fermented products.



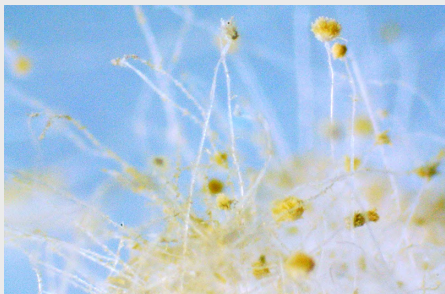
The soy sauce brewery on Shodo-shima Island. Countless microorganisms, including yeast and lactic acid bacteria relevant for fermentation, live in the wooden barrels that are vital for brewing.

1-2 Microorganisms that produce fermented foods

There are countless microorganisms that produce fermented foods. They are involved in fermentation and have individual characteristics that work differently from one another, but are common in that they decompose a certain substance and produce substances useful to humans. Here, we explain typical microorganisms involved in fermentation and their characteristics, as well as the roles they play in the process of fermentation, etc.

Asperugillus oryzae

Genus name:Aspergillus
Typical fungus:Aspergillus oryzae



Mold domesticated over the course of 1000 years

Asperugillus oryzae is a type of mold and is the generic name for filamentous fungi that are indispensable in Japan’s food culture. Asperugillus oryzae is used in many fermented seasonings and foods originating from Japan, such as miso, soy sauce, sake, vinegar, mirin (sweet sake used in cooking), and dried bonito. In 2006, it was designated as Japan’s national fungus by the Brewing Society of Japan. Asperugillus molds include not only Aspergillus oryzae, a typical mold of this genus used in koji for sake, miso, and rice vinegar, but also other several kinds used in koji for soy sauce, shochu (distilled spirit), and Awamori (distilled spirit of Okinawa).

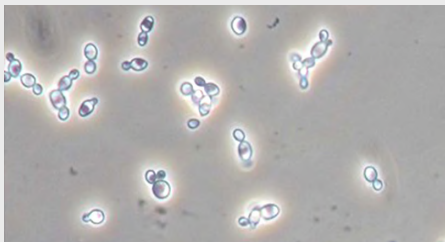
Koji is a cereal or legume in which Asperugillus oryzae has been propagated, and is available in different types including: rice koji made of rice, barley koji made of barley, and bean koji made of soybeans. Japanese people have produced various fermented foods by taking advantage of koji. There are two kanji characters for koji: one is 麹 and another is 花, where 米 means rice and 花 means flower. The latter kanji character represents white spores of Aspergillus oryzae propagating on rice like flowers, and speaks to the unique sensibility of Japan.

Tane-koji (spore of Aspergillus mold) dealers have existed as a traditional

business in Japan, from which brewers around the country purchase Tane-koji to produce koji. Thus, Asperugillus oryzae has been managed carefully by specialized dealers and can be said to be a mold domesticated by humans. Recently, the results of genomic analyses of Aspergillus oryzae demonstrated that unlike wild varieties, Aspergillus oryzae used as Tane-koji do not have genes that produce poisonous substances. This scientifically demonstrates the safety of koji, guaranteed by the 1,000-year long history of Japan’s koji culture.

Yeast

Genus name:Saccharomyces, Zygosaccharomyces
Typical fungus:Saccharomyces cerevisiae, Zygosaccharomyces rouxii



Source of the flavors of Japanese food

Yeasts are everywhere in the world of nature: in the air, in the soil, in water, and on the surface of plant leaves and fruits. The yeast that is most widely used in fermented foods around the world is Saccharomyces cerevisiae.

Yeasts have a high capacity to change glucose into alcohol and carbon dioxide. With this capacity, yeasts are used mainly to brew beer, wine, sake, and other alcoholic beverages, and are also used in the process of bread production to raise bread dough and produce unique flavors. Beer and bread, which are made of malt

and flour, respectively, are produced by almost the same process.

The unique flavor of soy sauce is also produced by a yeast. Soy sauce contains a component with a caramel flavor called HEMF, which characterizes its flavor. HEMF is a substance produced from soy sauce components by a yeast. Consequently, koikuchi soy sauce in particular, which has been well-fermented by a yeast, contains a rich amount of HEMF. This type of yeast is also used to brew miso, and is salt-tolerant (halotolerant yeast). Halotolerant yeasts,

exemplified by Zygosaccharomyces rouxii, are indispensable for making Japanese salty fermented seasonings.

Globally, the term yeast generally refers to bread yeasts, and halotolerant yeasts are not often used outside Japan. The rich flavor of soy sauce produced by Japan’s own technologies for using yeasts has been integrated into the everyday life of Japanese people as an element that makes Japanese food tasty, and is a flavor that represents Japan.