Handbook of Molecular Gastronomy
Scientific Foundations, Educational Practices, and Culinary Applications
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Publication details
Ole G. Mouritsen
Published online on: 09 Jun 2021

Accessed on: 10 Oct 2023

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Texture: Tsukemono – the Art and Science of Preparing Crunchy Vegetables

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Tsukemono is a Japanese term for ‘pickled or steeped things’ and mostly applies to vegetables. It covers a wide range of one or more conservation techniques, involving ingredients such as salt, sugar, vinegar, alcohol, and herbs, in combination with methods including dehydration, marinating in salt and acidic liquids, fermentation, and curing. Apart from conserving the vegetables, these techniques lead to very crunchy and flavourful products.

One of the best-kept secrets of Japanese cuisine, which the wider world has yet to discover in depth, is a range of side dishes known as tsukemono (つけもの, pronounced like ‘tskay-moh-noh’) and literally meaning ‘something that has been steeped or marinated’ (tsuke – steeped; mono – things). While they may not yet have appeared over the horizon in Western cuisines, these pickles are just as common a part of every traditional Japanese meal – breakfast, lunch, and dinner – as cooked rice and miso soup. Tsukemono are usually made from vegetables, some fruits, and flowers, and a few rhizomes are also preserved in this way; it is, therefore, more accurate to characterize them as ‘pickled foods’. However, the process of making tsukemono is more than just a simple way of preserving otherwise perishable fresh produce (Richie, 1985; Yamaguchi, 1988; Shimizu, 1993; Andoh, 2010; Hachisu, 2015; Mouritsen and Styrbæk, 2021; Mouritsen, 2018).

Preparing tsukemono involves different salts, sugar, vinegar, alcohol, enzymatic and bacterial fermentation, as well as various pickling beds of miso, soy sauce, and sake lees. The pickling not only aids in conservation and enhancement of nutritional value; it also has significant effects on taste, aroma, and particularly mouthfeel. In many cases, the umami taste is increased, but the most striking feature of most tsukemono is its unique mouthfeel of crunchiness (Mouritsen, 2018). An understanding of the scientific mechanisms behind this texture involves the effect of ions, in particular divalent ions such as calcium and magnesium ions (from sea salt), pH, and enzymes. In many cases, the crunchy mouthfeel is enforced by first drying vegetables before marinating. It is generally a matter of changing the water activity in the vegetables.

Tsukemono are normally prepared without any cooking and are eaten cold, and they are generally easy to make at home. Apart from their nutritional value, their contribution is to stimulate the appetite, add delicious flavour sensations, and improve digestion, all while remaining an exceptionally elegant study in simplicity and aesthetic presentation.

It is worth noting that, in the Japanese kitchen, tsukemono are not just pickled foods that are served arbitrarily as condiments. They are an essential element of Japanese cuisine. On the surface, they have a Zen-like simplicity, but both their tastes and textures are very sophisticated. They are as much part of an ordinary meal as of a formal, classical kaiseki dinner. Commercially prepared tsukemono are sold in inexpensive plastic bags in supermarkets, but they can also be bought as much sought-after regional and seasonal specialities, elaborately packaged for presentation as highly prized gifts.

Tsukemono play a special role in relationship to cooked rice. In Japan, rice is usually prepared without salt and has a rather bland taste. Traditionally, tsukemono were served with a cup of green tea and a bowl of cooked rice at the conclusion of a meal or, possibly, as a snack at afternoon tea time. Things have changed, and a small serving of tsukemono may make an appearance before, during, or after a Japanese meal. In addition, they are often combined with other types of food.

It is said that there are about 4000 different kinds of tsukemono in Japan and more than 100 different ways of preparing them. Some examples are shown in Figure 89.1. This overabundance of choice can be overwhelming, especially when compared with the number of pickled products that are common in Western cuisines.

Preparation of Tsukemono

Tsukemono can be made from virtually any kind of vegetable, as well as fruit, seaweeds, fish, shellfish, and even flowers. The different varieties and the techniques related to preparing them are both denoted by the same word, which always ends with -zuke. For example, miso-zuke refers to both a method and its end product. The many different ways of preparing tsukemono are a reflection of the need to conserve these fresh ingredients for extended periods of time, up to several years. The advent of
FIGURE 89.1 An assortment of tsukemono.
(Courtesy of Jonas Drotner Mouritsen)
freezers and refrigerators has completely altered the landscape, and there are now many types of tsukemono that have a much shorter shelf life than earlier versions (Mouritsen, 2018).

Tsukemono are often classified into two different categories that are distinguished by the duration of their pickling time. Some of these require little effort and result in simple foods that will keep for only a few days. Those that can be prepared quickly, for example, asa-zuke, or ‘quick pickles’, are marinated in salt or in weak brine for a few hours or days. They usually need to be kept refrigerated and are eaten within a few days. The others, called furu-zuke, require long, elaborate preparation, conservation, and ageing for periods that range from a few weeks to a year or more, and will keep for months and up to several years. As long as they are stored in a dark place and in the original pickling crocks to keep them from drying out, they do not need to be cooled. The differences in preparation and ageing times are reflected in distinct variations in flavour and smell. A common trait, however, is that most tsukemono made from vegetables are crisp and so crunchy that every bite releases an explosion of taste and aroma. Some Japanese chefs describe this experience as a taste with long duration, much as the French use longueur en bouche to describe the finish and aftertaste of wine.

The various techniques for preparing tsukemono can be divided into ten basic types that are sometimes used in combination (Table 89.1). These types correspond to three different procedures: marinating in liquid, preserving in a paste, where there may also be a simultaneous fermentation process, and a genuine fermentation process mediated by enzymes and microorganisms such as fungi, yeasts, and bacteria. With all three methods, the addition of salt, either directly or indirectly from other ingredients, is the most essential element. If a paste is involved, it is normally wiped off, either completely or partially, before the preserve is eaten. Both the liquid marinade and the paste can be flavoured with spices and additives, such as Japanese chili (togorashi), Japanese pepper (sansho), mustard (karashi), ginger, yuzu, shiso, and seaweeds (konbu, wakame, nori, ao-nori). The preparation technique for a particular vegetable or fruit is chosen in order to enhance its distinctive character, texture, and flavour.

It is, by far, easiest to work with liquid marinades consisting, for example, of brine, soy sauce, sake, or vinegar. Using fermentation media containing pastes and fungus cultures is more complicated, but the reward is a considerably more nuanced flavour. In some instances, several preservation media, with different effects, are used in combination. For example, a marinade may consist of soy sauce, sake, and sugar or may be a mixture of miso and sake lees. In the case of some vegetables, dehydrating the vegetables before they are preserved results in a much crisper and crunchier mouthfeel. Those that are to be immersed in a thick paste, generally for several weeks or months, must be desiccated first, otherwise the preservation medium becomes too moist. Dehydration can be carried out using salt, according to old-fashioned methods out of doors, or with the help of a dehydrator.

### TABLE 89.1
Ten Generic Ways of Preparing Tsukemono

<table>
<thead>
<tr>
<th>Type of tsukemono</th>
<th>Preparation technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shio-zuke</td>
<td>curing in salt</td>
</tr>
<tr>
<td>Su-zuke</td>
<td>curing in vinegar</td>
</tr>
<tr>
<td>Sato-zuke</td>
<td>curing in sugar</td>
</tr>
<tr>
<td>Amazu-zuke</td>
<td>curing in vinegar and sugar</td>
</tr>
<tr>
<td>Shoyu-zuke</td>
<td>curing in soy sauce</td>
</tr>
<tr>
<td>Karashi-zuke</td>
<td>curing in mustard</td>
</tr>
<tr>
<td>Nuka-zuke</td>
<td>fermenting in rice bran</td>
</tr>
<tr>
<td>Kasu-zuke</td>
<td>curing in sake lees</td>
</tr>
<tr>
<td>Miso-zuke</td>
<td>curing in miso</td>
</tr>
<tr>
<td>Koji-zuke</td>
<td>fermenting in koji</td>
</tr>
</tbody>
</table>


### Salt, Salts, and Texture

With the exception of sato-zuke, which are sweet, every type of tsukemono is made with salt that is added either directly or indirectly from other sources such as soy sauce and miso. Originally, a high salt concentration, often as great as 8–10%, was an important factor in ensuring that the pickles would keep for a long time. And as a further precaution, the tsukemono were traditionally stored in the darkest, darkest part of the house. Refrigeration and freezing have radically altered the picture. With the addition of preservatives and the use of effective cooling techniques, the salt content has now been reduced to 3–4%, even for the tsukemono that are intended to have a long shelf life. Some modern varieties are also pasteurized, vacuum packed in plastic bags, and kept refrigerated. Here, the primary role of salt is its effect on taste, mouthfeel, and digestibility. In all circumstances, the salt content of a given product is a question of striking a balance between flavour and conservation.

The simplest way to make tsukemono is basically just to marinate the ingredients in brine containing 5–25% salt. Ordinary table salt (impure NaCl), which has a dependably uniform composition, is not used exclusively. In Japan, it is traditional to choose instead from a variety of sea salts. These may contain additional salt compounds, e.g., potassium, magnesium, and calcium salts, as well as substances, such as seaweed ash, that are actually desirable impurities. It is, therefore, crucial to select the right type of salt, as these differences completely determine the outcome of the pickling process with respect to both the taste and texture of the resulting tsukemono.

The salt used to prepare tsukemono draws liquid out of the cells and destroys them, rendering the vegetables rather soggy, as shown in Figure 89.2. This releases their enzymes, which assist in the process of degrading many of the bitter substances present in raw vegetables, leaving them with a milder, sweeter taste. At the same time, microorganisms, such as yeast and bacteria, may begin their work of breaking down the plant matter. This brings about the formation of a whole new series of taste substances, counteracts the impression of saltiness, and leads to rounder, softer taste nuances. In addition, the salt prevents the growth of unwanted bacteria.
Tsukemono can become extra crisp if they are preserved using sea salt that contain calcium and magnesium salts. Ions from these two salts cause the carbohydrates in the vegetables, for example, pectin, to form strong bonds, a process known as cross-binding (Figure 89.3), resulting in a very firm and crisp mouthfeel. This is exactly the same mechanism used to make jelly and other hydrogels from alginate, a gelation agent extracted from seaweeds.

Many of the soluble dietary fibres, for example, pectins, are found in the cell walls of plants. Pectin molecules in an aqueous environment are, depending on pH, negatively charged and repel each other. In order to bind the pectin molecules tightly together and form a firmer structure together with the water, it is necessary to counteract this repulsion. One way to do so is to add sugar (sucrose), which binds water and, as a consequence, forces the pectin molecules to link together a little more strongly. Another possibility is to add acid, which reduces the extent of the electric repulsion. Still another option is to introduce calcium ions or magnesium ions, which have a positive charge and in this way bind the negatively charged pectin molecules more strongly together. The ability of calcium ions to stiffen foodstuffs that contain pectin can be exploited to ensure that cooked or pickled vegetables remain firm. It is simply a matter of adding sea salt or a pure calcium salt such as calcium citrate.

Drying and Texture

Preserving vegetables is partly a matter of reducing their water content, but it is not necessary to remove it entirely. Surprisingly, one of the most effective ways of imparting crispness to tsukemono involves pre-drying of the vegetables so that they lose 40–80% of their fresh weight (Figure 89.4). As described in another chapter in the present volume (on Imaging by Clausen et al.), dehydration is hard on the cells of the vegetables; it changes their shape, and the cell walls can be broken, altering the texture of the vegetable. The sugar content of the dried vegetable also affects its texture. One with more sugar will be chewier and more flexible. Sugar binds the water and will also cause water to be absorbed from the surroundings. Vegetables with a great deal of soluble dietary fibre, such as pectin, that binds water less strongly than sugar have a tendency to turn out more crunchy than those with a high sugar content.

Typically, the temperature in a vegetable dehydrator is kept in the range of 40–60 °C in order to preserve colour as well as taste and aroma. The partial dehydration of the vegetables diminishes the growth of bacteria and enzymatic activity on their surfaces, thus lessening the risk of deterioration. Nevertheless, drying in itself is not sufficient to preserve the vegetables; this will require the addition of salt.
Texture: Tsukemono

It is the very special crunchy texture and mouthfeel that furnishes the unique flavour experience of tsukemono (Mouritsen and Styrbæk, 2017). Apart from this special mouthfeel of tsukemono, the main common flavour characteristic is umami. Most vegetables have little umami in their fresh state (Mouritsen and Styrbæk, 2017). However, via the various ways of preserving them, in particular via pickling beds involving fermented products like soy sauce, miso, and sake lees, or by active lactic bacteria fermentation in, e.g., a nuka-doko fermentation bed, the vegetables are imparted or develop a host of odour and taste compounds, including glutamate, which leads to the umami taste.

Flavour

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Aesthetics and Health

Tsukemono evolved in Japan as tasty, nutritious condiments for a simple bowl of cooked rice. Although tsukemono could be placed on top of the rice, they are now presented separately on a small dish or in a small bowl. The presentation is simple and consists of only very small amounts; it is just as much a matter of what is not there as of what is there – it is a matter of wabi. They are usually offered as a small selection of pieces, arranged separately on a dish or in a bowl. The empty spaces between them are just as important as the actual tsukemono. The choice of colours, sizes, and shapes is of key importance, in the same way as it is in the traditional Japanese meals washoku, kansha, and kaiseki. Harmony in all sensory impressions is centre stage.

Tsukemono are meant to be eaten in small quantities selected from a variety of different types. These tasty, nutritious condiments were, in the first instance, a simple staple that was used to round out an ordinary meal of plain boiled white rice and miso soup. But despite their humble origins, they were also considered sufficiently sophisticated to be integrated into temple foods and very elaborate dinners. Virtually no meal in Japan is now served without at least a little tsukemono, and even in the most modern households, a few pieces usually find their way onto the plate. It is the contention of the present author that tsukemono has a lot to offer to Western gastronomy.

In Asia, and particularly in Japan, tsukemono are considered healthy foods (Murooka et al., 2008), because, apart from their content of macronutrients like proteins and carbohydrates, they are a source of important minerals, vitamins, and antioxidants, as well as soluble and insoluble dietary fibres. The fact that these pickles, whether or not they are fermented, are produced without heating implies that many nutrients, vitamins, and active enzymes are better preserved than those in vegetables that have been cooked. A possible drawback may be that some of these desirable components, such as proteins, are less bioavailable during digestion than those in cooked vegetables. Finally, it should be pointed out that the salt content in tsukemono has been linked to health issues regarding hypertension and certain cancers (Ren et al., 2012).

Acknowledgements

This work was supported in part by a grant to Smag for Livet (Taste for Life) from Nordea-fonden. Mariela Johansen is thanked for her diligent work on translating some of the authors’ texts from Danish into English.

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