Government of Western Australia
Department of Health

Risk assessment and legislative requirements for fermented foods

Information for local government Food Act 2008 authorised officers

This guide provides information to assist *Food Act 2008* (Food Act) authorised officers when assessing a proposal for the manufacture of fermented food intended for sale in Western Australia. This guide will provide an overview of the risk assessment of two different fermented products - kimchi and kombucha.

Background

The early definitions of fermentation referred to an anaerobic process using yeast to convert sugars to ethanol and carbon dioxide. The modern definition of food fermentation refers to a food processing technology used to promote the growth and metabolic activity of microorganisms for the purpose of stabilisation and transformation of food materials.

The traditional view on risk assessment of fermented foods, was primarily aimed at risk characterisation of a single ingredient and/or single process. Today the accurate and effective risk assessment of various food commodities, including fermented foods, is based on a detailed case by case risk assessment, where complex food mixtures and different processing methods need to be considered.

This guide provides specific information to local government about the:

- manufacturing process of kimchi and kombucha,
- various hazards associated with these types of foods, and
- the different factors affecting fermentation.

History of fermented foods

Food fermentation was initially used to preserve foods, extend product shelf life, and improve food flavour. It is one of the oldest known uses of biotechnology. Fermented drinks, traditional breads and fermented vegetables are examples of the first known fermented food products.

There are two main methods of how food can be fermented.

- **Natural method**

  The microorganisms are naturally present in the raw food or food manufacturing environment e.g. sauerkraut, kimchi, and some fermented soy products.

- **Controlled fermentation**

  Food is fermented via addition of starter cultures e.g. kombucha, kefir and Japanese natto.

Classification of fermented foods

Based on biochemical pathways, foods produced by fermentation can be classified into four categories:

- **Acetic acid fermentation**

  This is a process of converting ethyl alcohol into acetic acid using fermenting bacteria. Examples include apple cider vinegar, coconut water vinegar and kombucha.

- **Alcoholic fermentation**

  This is a complex biochemical process, where yeasts are used to convert sugars to ethanol, carbon dioxide, and other metabolic by-products. Examples include alcoholic beverages such as wine and beer.

- **Lactic acid fermentation**

  This is an anaerobic microbial process in the breakdown of sugars yielding energy and releasing waste products, specifically lactic acid. Examples include fermented milks, yogurts, meats, sourdough bread and pickled vegetables.

- **Alkali fermentation**

  This is a process where the increase of pH up to 8 triggers the metabolic activities of microbes that breakdown the protein of the raw material into amino acids, peptides and ammonia. This process is responsible for the fermentation of legumes, protein oil seeds and Japanese natto.

Kimchi

Kimchi is a probiotic lactic-acid bacteria (LAB) traditional in Korean fermented vegetable food. It is made using various vegetables with the main ingredient being kimchi cabbage (*Brassica pekinensis*). The vegetables are brined and mixed with other ingredients, such as radish, ginger, garlic, green onion and red pepper powder, followed by fermentation at a low temperature. Currently, there are more than 200 different varieties of kimchi, depending on various raw materials and processing methods used.

General kimchi process summary

The basic manufacturing process consists of the following steps. Cabbage is mixed with salt and kept at room temperature for between 3-6 hours to encourage salt penetration. The product is then rinsed, drained and mixed with prepared seasonings to further encourage brine formation and the removal of sugars. The product safety and complex flavour profile are achieved during the next stage, through a fermentation process, where the product is required to reach pH ≤4.6, which is the main Critical Control Point (CCP) of this product. Different combinations of fermentation time and temperatures are used in different recipes. After fermentation the kimchi is covered and refrigerated at ≤ 5°C and then ready to consume. In some cases, additional thermal processes and/or use of food additives may be employed, which would introduce additional process CCPs.

Kimchi basic process flow

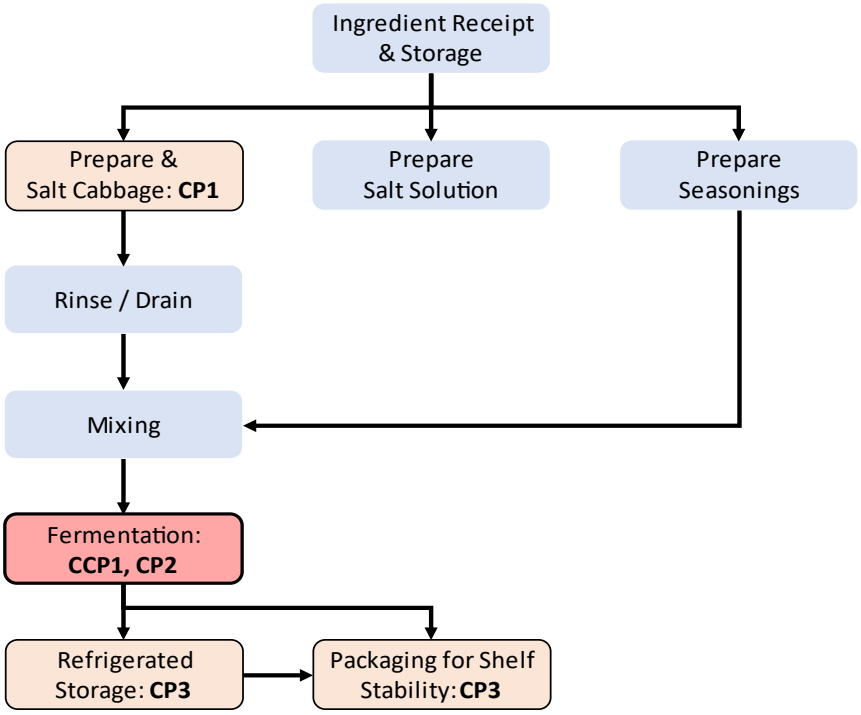

FIGURE 1: Flow chart of typical kimchi-making process

Note: CP – Control Points, **CCP** – Critical Control Point

Source: Manufacture of Traditionally Fermented Vegetable Products: Best Practice for Small Businesses and Retail Food Establishments (Abigail Snyder, Fred Breidt, Jr., Elizabeth L. Andress and Barbara H. Ingham, 2020).

Food safety hazards associated with kimchi

The main food safety hazards for this product can be divided into four categories: physical, chemical, environmental and biological.

- **Physical hazards**

  Include the presence of foreign matter in processed foods, such as metal, glass, stone, soil, plastic objects and/or particulate matters found in brines and in seasonings.

- **Chemical hazards**

  Include cleaning agents being used incorrectly and other chemical contaminants like allergens.

- **Environmental hazards**

  Other chemical hazards of environmental origin such as heavy metals and pesticides may also be associated with vegetable safety.

- **Biological hazards**

  Kimchi like many other traditionally made non-thermal (uncooked) foods, is limited in the methods used to control hazardous microorganisms. Furthermore, spontaneous fermentation can be exposed to other sources of contaminants, including pathogens, during the manufacturing process. Pathogenic microorganisms detected in kimchi products have been reported and include *E. Coli*, *Salmonella spp*., and *Staphylococcus aureus*.

Kombucha

Kombucha is a traditional Asian beverage that originated in Northeast China and is made from the fermentation of tea and sugar by bacteria and yeast. The process uses yeast to ferment the sugar to alcohol followed by a bacteria fermentation of alcohol to acetic acid similar to the fermentation of vinegar.

General kombucha process summary

There are many different processing steps for how kombucha tea can be made, but this document will focus on the basic steps of a traditional recipe. The first step consists of heating water to 100°C for a few minutes and adding tea leaves. After approximately 10 minutes, tea leaves are removed, sugar is added, and the tea is left to cool from 60°C to 20°C within 2 hours. The next stage is inoculation where a starter culture, called a Symbiotic Culture of Bacteria and Yeast (SCOBY) is added. To ensure product safety, a commercial starter culture should be used. The next step is fermentation, which may take 7-10 days, and the temperature during this stage should remain between 20°C to 23°C. Product pH should be checked through the entire fermentation stage to ensure that the product reaches pH ≤ 4.2. This step is recognised as a Critical Control Point (CCP) to prevent the potential growth of acid resistant pathogens. When the product reaches a safe level of acidity, the starter culture should be removed, and the final product would need to be refrigerated at 4°C.

It should be noted that modern versions of kombucha products may have different flavouring ingredients, including various juices, citric and other acids, colour additives and stabilisers. As result, different recipes and different processing steps require additional CCPs.

In order to control ethanol concentration in kombucha products, brewing companies utilise the following strategies:

- Slowing yeast growth, and in some cases using microfiltration to remove yeasts from cultures.
- Utilising a lower temperature during brewing stage.
- Exposing the brew to oxygen through fermentation stage.
- Applying a gentle pasteurisation of the product at bottling stage.
- Controlling temperature through all processing stages, including the distribution chain.
- Employing food preservatives such as sodium benzoate and potassium sorbate.

Kombucha basic process flow

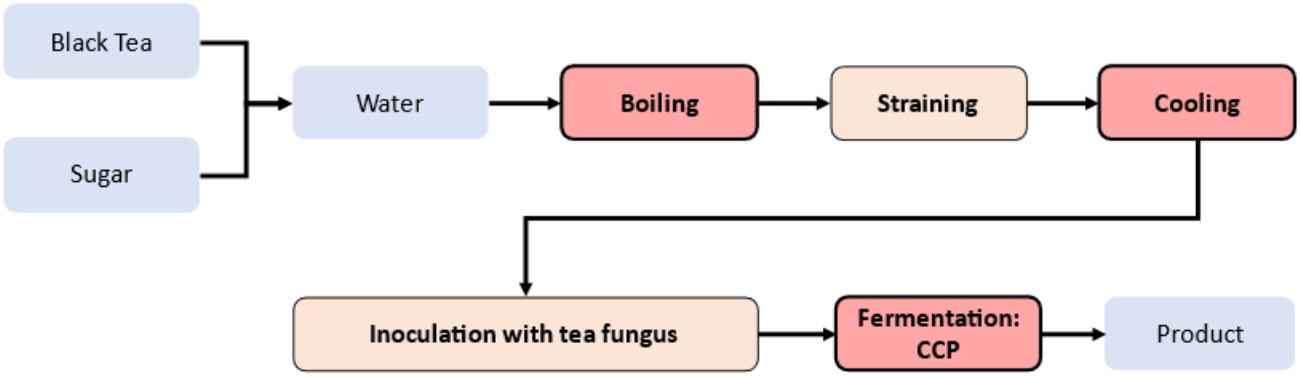

FIGURE 2: Flow chart of basic kombucha tea making process

Note: Fermentation stage is the main **CCP pH ≤ 4.2**

Source: Foods That Heal, 2014.

Food safety hazards associated with kombucha

- **Physical hazards**

  Foreign matter such as plastic, metal and sand.

- **Chemical hazards**

  Acidosis, linked with kombucha product with a pH < 2.4, and alcohol toxicity, linked with cases of excess ethanol production during fermentation and post fermentation stage. Formation of carbon dioxide, has also been reported, resulting in excess pressure and the leakage of bottles.

- **Environmental hazards**

  Pesticide residues, elevated levels of heavy metals from different sauces, and fumigant residues commonly exposed during tea storage and transportation.

- **Biological hazards**

  Product contamination may occur during any stage of production, but it has been suggested that the most vulnerable stage is the inoculation stage, where unwanted pathogens or mould may grow. Scientific literature reports that different organisms such as: *Escherichia coli, Salmonella Typhimurium, Yersinia, Listeria monocytogenes*, and *Lactobacillus* have been present in tested samples, where they displayed a strong Acid Tolerance Response (ATR). This can be a problem if the fermentation step is taking too long, as it allows the acidification process to permit organism adaptation.

  Another biological hazard that has been reported in homemade kombucha production is contamination of the starter culture by mould, predominantly *Penicillium* or *Aspergillus* organisms.

Factors affecting fermentation

There are several important factors that should be taken into consideration prior to, and during the manufacturing process of any fermented food products. These factors will not only determine the quality of the finished product, but more importantly the safety of the product.

- **Solid - Salt Ratio** (for solid fermented products)

  Fermented food recipes use different salt concentrations, but to achieve a safe product a final salt concentration should be between 3-6%. The correct type of salt should be used, which is canning or pickling salt. Table salt or iodized salt should be avoided, since it may inhibit the fermentation process.

  Special attention should also be given to the type of water used in fermented recipes. Distilled water should be used to avoid problems with 'hard' and 'soft' water as mineral balance can influence fermentation.

- **Safety and quality of a starter culture**

  Significant consideration should be given to the safety and quality of a starter culture to ensure satisfactory and consistent fermentation results. Purchasing a starter culture that has a Certificate of microbial analysis and ensuring it is used in accordance with the manufacturer's instructions will minimise the likelihood of product contamination.

- **Fermentation time and temperature**

  Each product has an optimum combination of fermentation time and temperature that delivers a balance between quality and safety of the product. According to scientific literature, the optimal range of fermentation temperature for kombucha is between 23°C to 25°C. For kimchi products, the fermentation temperature is a few degrees cooler, between 18°C to 20°C. It is important to note, that the survival of harmful microorganisms in the final product, can result from slow fermentation, particularly during the initial fermentation period. However, rapid fermentation can also result in a poor quality product. According to Kombucha Brewers International, to prevent continued fermentation, and an increase in alcohol content, a cold storage temperature between 1.1°C to 4.4°C, is required throughout the whole supply chain.

- **Final pH of product**

  Monitoring the production of acetic acid in a timely manner and avoiding over production of acetic acid is a fundamental strategy linked with the main CCP of fermented products. The final pH value of fermented products should always be ≤4.6. The exemption to this rule is kombucha tea, where the safe product would require a final pH value of ≤ 4.2.

- **Hygiene and sanitation**

  Good Manufacturing Practices (GMPs) throughout the entire manufacturing process is required to prevent product contamination. This includes all utensils and vessels being clean and sanitised. The same principle should be extended to preparation and fermentation areas.

- **Equipment choice**

  In the case of manufacturing fermented beverages like kombucha tea, glass containers or food grade porcelain containers, should be used. This avoids the potential for acidic product to leach out chemical contaminants, such as lead. For this reason, crystal, coloured glass,

painted ceramic and metal containers should be avoided, as they can potentially leak harmful toxins into the brew.

- **Use of hurdle technology**

  Hurdle technology is a concept based on combining different preservation techniques as a preservation strategy. The most important hurdles widely used in food preservation are based on controlling temperature, water activity, acidity, modified atmosphere and competitive microorganisms (e.g. lactic acid bacteria). Presently, a specific example of hurdle technology is used where naturally occurring antimicrobial agents are used as preservatives to extend the shelf life of kimchi. Their main purpose is to prevent over-acidification, as a result of continued fermentation of kimchi during storage and distribution.

Legislative requirements for fermented foods

Relevant definitions

Under the Australian New Zealand Food Standards Code (the Code) Standard 2.5.3 - 2

- ***fermented milk*** means a food obtained by fermentation of milk or products derived from milk, where the fermentation involves the action of microorganisms and results in coagulation and a reduction in pH.
- ***yoghurt*** means a fermented milk where the fermentation has been carried out with lactic acid producing microorganisms.

  2.5.3—3 Requirement for food sold as fermented milk or yoghurt

  A food that is sold as fermented milk or 'yoghurt' must:

  (a) be fermented milk or yoghurt as appropriate, or of fermented milk or yoghurt with other foods added; and

  (b) have a pH of no more than 4.5; and

  (c) have no less than 10^6 cfu/g microorganisms used in the fermentation; and

  (d) if the food is derived from cow's milk—contain no less than 30 g/kg protein (measured as crude protein).

Under the Australian New Zealand Food Standards Code (the Code) Standard 2.6.2-2

- A ***brewed soft drink*** means a food that is:

  (a) is the product prepared by a fermentation process from water with sugar and one or more of:

  (i) fruit extractives or infusions; or

  (ii) vegetable extractives or infusions; and

  (b) contains no more than 1.15% alcohol by volume.

Labelling and licensing requirements

According to Standard 2.7.1 of the Code, a declaration statement regarding alcohol content is required for a beverage that contains 0.5% or more alcohol by volume

In Western Australia, the *Liquor Control Act 1988*, defines liquor for the purpose of supply, sale and consumption, as any beverages containing more than 1.15% alcohol (ethanol) by volume (ABV) that would require a liquor license.

Resources

- Starting a food manufacturing business fact sheet
- Assessment of businesses that manufacture food factsheet
- Food recalls factsheet
- Food Industry Recall Protocol
- FSANZ Review of microbiological limits
- FSANZ Compendium of Microbiological Criteria for Food

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