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THE OXFORD HANDBOOK OF

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**FOOD**

**FERMENTATIONS**

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**OXFORD**  
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## CHAPTER 14

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# ASIAN FOODS

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M. J. ROB NOUT, CHERL-HO LEE, AND BEI-ZHONG HAN

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### 14.1 INTRODUCTION

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ASIA covers a vast surface area and includes a large diversity of climates and peoples. It is therefore not surprising that one encounters a variety of food crops and sources of animal food according to tropical, subtropical, moderate, and alpine regions. People's cultures, (food) habits, and preferences are narrowly connected to their living conditions. The same can be said for the microorganisms that are exploited in the processing of fermented foods, ranging from thermophilic to mesophilic phenotypes. In the past, people lived without food preservation aids such as refrigerators or freezers, and they lacked fuel-economic cooking apparatus. Therefore, traditional ways of food processing were aimed at food preservation and economy of fuel use. It was learned that so-called wet processes saved fuel by reducing cooking times and that fermentation could contribute to longer shelf life of foods. In nomadic tribal life, people and animals had to travel frequently and could not afford to transport large volumes of bulky food. The origin of cheesemaking was borne from the necessity to concentrate milk into 10% of its original volume in the form of protein concentrate. A similar principle is found in the processing of soybean milk into its compacted form, tofu. Another processing aid that played an important role as a food preservative is salt. Application of salt has been combined frequently with fermentation; the presence of salt has a selective effect on microorganisms that dominate the microbiota responsible for the fermentation.

In this chapter, attention is given to fermented food products made from major primary produce, such as soybeans, cereals, and meat. For vegetable fermentations see chapter 10 and for fish fermentations, chapter 18. A selection is made of representative fermentations in Asian countries or subregions, with an attempt to describe fermentations dominated by different types of microorganisms: bacteria, yeasts, and filamentous

fungi (molds). Since salt has its specific effect, fermentations are distinguished according to the inclusion of salt.

In addition to a description of the nature of the food, an introduction is given about the scientific knowledge referring to its production, microbiological, and chemical composition and (bio)chemical changes taking place during the fermentation.

The production processes of some traditional fermented food products have undergone an industrial metamorphosis. As a result of empirical and scientific experimentation, the mechanisms of the fermentation, the identity of functional microbiota, and the chemical basis of the quality of these products are better understood. This contributes, together with good marketing and distribution logistics, to an increased national and international consumer market. Examples of such highly industrialized products are described, as well as products that are still made at the artisanal level. Where possible, future trends of scientific and technological development are indicated, as markers for potential industrialization.

The products discussed in this chapter are listed and characterized in Table 14.1. They represent important food crops that are hard to eat in their natural form or that are perishable and need to be preserved.

The first category (i.e., hard to consume) is represented by soybeans. Although unprocessed soybeans appear interesting from a nutritional point of view because of their high levels of protein and fat, they are naturally well-protected by "antinutritional factors" that hinder digestion (trypsin inhibitors) or that even could lead to damage of the intestinal epithelium (lectins, haemagglutinins). Such factors could be removed or inactivated by soaking and cooking soybeans, but these remain hard to digest because of their poorly digestible carbohydrate fractions. These limitations may explain the diversity of creative attempts to make soybeans more tasty and digestible. The enhancement of taste in fermented soybeans is due, among other things, to the release of free glutamic acid, one of the major amino acids in soybean protein. Glutamic acid is the principle of the "umami" taste and enhances the meaty flavor of chicken. To degrade soybean protein and carbohydrates, the fermentation should result in the formation of proteolytic and carbohydrate degrading enzymes. From Table 14.1, it is evident that *Bacillus* spp. and diverse filamentous fungi (*Rhizopus*, *Aspergillus* spp.) are used for this reason. The use of salt, either rock salt or a salt solution (brine), protects the product from spoilage during long-term maturation periods; salt also serves to activate enzymes and is thus used as a process aid.

Fish, vegetables, and meat are perishable. The major priority is to preserve them, and this can be achieved by adding salt or by lowering the pH. Both approaches are encountered, singly or combined. In this chapter, only meat preservation by curing and fermentation is discussed.

The third aspect, in addition to edibility and preservation, is attractiveness. Cereal starch has traditionally been an ingredient of foods and beverages intended for pleasure, especially after degrading it to fermentable sugars (maltose, glucose) and their conversion by alcoholic fermentation. Although beers are beyond the scope of this chapter, alcoholic fermentation is also essential in the manufacture of leavened bread

Table 14.1 Asian Fermented Foods

Major Ingredients	Name and Origin	Product Characteristics	Fermentation	Salt (NaCl) Use	Microbiota	Key References
Soybean Soybean sauce	Chinese <i>jiangyou</i> , Japanese	Liquid hydrolysate	SSF followed	Yes	Pure culture mold and lactic	Aidoo et al 2006

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**Table 14.1 Asian Fermented Foods**

Major Ingredients	Name and Origin	Product Characteristics	Fermentation	Salt (NaCl) Use	Microbiota	Key References
Soybean	Chinese <i>jiangyou</i> , Japanese <i>shoyu</i>	Liquid hydrolysate from soybeans and cereals	SSF followed by BM	Yes	Pure culture mold and lactic acid bacteria starters	Aidoo et al. 2006; Jin et al. 1998
		Liquid hydrolysate from soybeans only	SSF, followed by BM	Yes	Natural fermentation starters (molds, yeasts, lactic acid bacterial)	Lee 1990
Soybean paste	Chinese <i>doujiang</i> , Korean <i>doenjang</i> , Korean <i>kochujang</i> , Japanese <i>miso</i> , Indonesian <i>taoco</i> , Korean <i>chongkukjang</i>	Soybean paste	SSF	Yes	Molds and bacilli	Kim et al. 2010; Li and Ma 2003; Lim 1991
		Other soybean products				
Other soybean products	Nepalese <i>kinema</i>	Slimy fermented crushed soybeans	SSF	No	Bacilli	Sarkar et al. 1994
		Slimy fermented whole soybeans	SSF	No	Bacilli	Murooka and Yamshita 2008
		Mold-fermented whole cooked seeds (mainly soybeans)	SSF	No	Molds	Nout and Kiers 2005
		Fermented whole black soybeans	SSF	Yes	Molds	Zhang et al. 2007
Fish (see chapter 18)	Chinese <i>douchi</i>	Mold-fermented tofu matured in brine	SSF-BM	Yes	Molds	Han et al. 2001b
		Chinese <i>furu</i> ( <i>sufu</i> )				
Fish (see chapter 18)	Fish sauce and paste	Liquid fish hydrolysate	SSF	Yes	Halotolerant lactic acid bacteria	Lopetcharat et al. 2001

(Continued)

**Table 14.1 Continued**

Major Ingredients	Name and Origin	Product Characteristics	Fermentation	Salt (NaCl) Use	Microbiota	Key References
Vegetables (see chapter 10)	Korean <i>sikho</i> e	Fermented fish mixed with millet, garlic, pepper	SSF	Yes	Lactic acid bacteria	Lee et al. 1983
	Korean <i>kimchi</i>	Fermented whole Korean cabbage, radish, garlic, etc.	SSF	Yes	Lactic acid bacteria	Lee et al. 2005
	Chinese <i>yanzicai</i> , Japanese <i>asazuke</i>	Chinese cabbage, radish, cucumber, potheb mustard	BM	Yes	Lactic acid bacteria	Zhao et al. 2007
Meat	Vietnamese <i>nem chua</i>	Fermented chunks of pork meat	SSF	No	Lactic acid bacteria	
	Chinese <i>Xuanwei ham</i>	Cured and fermented ham	SSF	Yes	Molds, yeasts, lactic acid bacteria	Li et al. 2008
Cereals	Chinese vinegar	Liquid extract of molded and oxidized mass of sorghum and rice husks	SSF	No	Molds, yeasts, acetic acid bacteria	Liu et al. 2004
	Leavened bread, sourdough bread, <i>naan</i> , <i>montou</i>	Over-baked or steamed fermented dough of wheat and/or rye flour	SSF	Yes	Yeasts, lactic acid bacteria	Gori et al. 2010
	<i>idli</i> , <i>puto</i> , <i>kichudok</i> , hopper	Steamed or baked fermented dough of rice and black gram	SSF	No	Lactic acid bacteria, yeasts	Aidoo et al. 2006; Koh and Singh 2009
	<i>angkok</i> (red kojic rice)	Fermented whole grains of rice	SSF	No	Molds	Ma et al. 2000

Fig. 14.11 Solid state fermentation

because the col structure. Mos in stirred tank larly Chinese, degraded by fi followed by starch-degrad microorganism The purpose and their enzymes that fermenters belong to releases primary tin molecules. used as ferment sorghum, the be used. Within the v some categorie (i) *Koji*: mi are used fungi pr starchy (ii) *Meyu*: a made in inside. (iii) *Nuruk* *Rhizopus* spp.; an starters; wet grits, wet mass of l the man *daqu* the in the m ghum (Z their brai (iv) *Murcha*: (Indones *bubod* (I

because the coproduced carbon dioxide inflates the bread dough and gives it its porous structure. Most vinegars of the West are produced by acetic acid bacteria in liquid form in stirred tank reactors, from wine or fermented wort. In contrast, Asian, particularly Chinese, vinegars are made from cereals such as sorghum or rice, which are first degraded by fungal solid-state fermentation (SSF) and yeast alcoholic fermentation, followed by oxidation of the alcohol in SSF heaps. In order to start this and similar starch-degrading fermentations, special starters are required containing amylolytic microorganisms.

The purpose of amylolytic fermentation starters is to deliver microorganisms and their enzymes to degrade precooked starch into glucose and to supply organisms that ferment glucose into alcohol and flavor. In most cases, the starch degraders belong to the filamentous fungi, which form amyloglucosidase, an enzyme that releases primarily D-glucose from the nonreducing ends of amylose and amylopectin molecules. The alcoholic fermentation is mostly performed by yeasts. The starch used as fermentation substrate mostly originates from cereals such as glutinous rice, sorghum, wheat, and millet, but starchy roots such as cassava and tubers can also be used.

Within the wide diversity of amylolytic starters, Hesseltine et al. (1988) distinguished some categories of distinct composition and use, as is shortly explained below.

- (i) *Koji*: mixed pure-culture conidia of *Aspergillus oryzae* and *Aspergillus soyae* that are used in the manufacture of soybean sauce, miso, and similar products. These fungi produce a range of enzyme activities including amylases, which act on the starchy components of the ingredient mix.
- (ii) *Meju*: a nonamylolytic soybean fermentation starter using cooked soybean only, made in a brick or ball shape, where molds grow on the surface and bacteria inside.
- (iii) *Nuruk* and *daqu*: mixed starters containing filamentous fungi (*Aspergillus*, *Mucor*, *Rhizopus*, *Penicillium*, *Absidia* spp.), yeast (*Pichia*, *Issatchenkia*, *Saccharomyces* spp.), and bacteria (*Bacillus* spp.). Korean *nuruk* and Chinese *daqu* are used as starters in the manufacture of alcoholic beverages. *Nuruk* is made from wheat grits, wetted and pressed to make a disk-shaped mass, and natural SSF for several weeks (Lee 2001). In *daqu*, the mixed microbiota has grown in a brick-shaped mass of barley and peas. During the months-long fermentation taking place in the manufacture of *daqu*, flavor compounds are produced as metabolites. The *daqu* therefore is not only a supply of microorganisms and enzymes, but it is also a flavoring agent for the product to be fermented. *Daqu* is used as a starter in the manufacture of Chinese liquor and vinegar. Liquor is made from sorghum (Zheng et al. 2011) and vinegar from rice and several other cereals and their bran;
- (iv) *Murcha*: this category is known in Asia under a range of names such as *ragi* (Indonesia; Dwidjoseputro and Wolf. 1970), *men* (Vietnam; Dung et al. 2007), *bubod* (Philippines; Kozaki and Uchimura 1990), and *loogpang* (Thailand;

Limtong et al. 2002). These are mixed starters dominated by mucoraceous molds (*Rhizopus*, *Mucor*, *Amylomyces* spp.), yeasts (*Candida*, *Endomyces*, *Hyphopichia*, *Saccharomyces* spp.), and lactic acid bacteria (*Enterococcus*, *Pediococcus* spp.). In principle this category of starters is grown in a dough of rice or wheat flour, allowed to proliferate during one to two days and then dehydrated under mild conditions to preserve microbial viability and enzyme activity. They are used to saccharify cooked starch (glutinous rice, cassava, millet) and bring about some extent of lactic acid fermentation and alcoholic fermentation. These fermentations usually take 24 to 72 hours and may result in products ranging from sweet and sour snacks (Indonesian *ape*; Cronk et al. 1977), primitive sour and alcoholic beers (Tibetan *jnard*; Tamang et al. 1988), to rice wine and liquor (Vietnamese *ruou nep than*; Dung et al. 2007).

The *koji* starters (category i) are mentioned in this chapter in Section 14.2 on fermented soybean products. The use of *meju* starter (category ii) is discussed in the section on soybean sauces (*ganjang*). *Daqu* (category iii) is an important starter and enzyme-rich ingredient in the manufacture of Chinese liquor and vinegars. The latter type of products is discussed in Section 14.4: "Cereal Products." *Murcha* and similar starters (category iv) have been reviewed extensively as mentioned above.

In conclusion, fermentation offers a range of options to enhance edibility, digestibility, and shelf life of primary products according to traditional technologies. Obviously, present-day technological infrastructure could achieve these objectives by alternative means. However, consumers have become so used to the flavor and other characteristics of traditional fermented food products that these actually serve as the benchmark when modernizing or designing more efficient industrial processes.

## 14.2 FERMENTED SOYBEAN PRODUCTS

### 14.2.1 Overview

Fermented soybean products are found under a variety of common names used in the countries of origin. To the newcomer, it is an almost confusing diversity of products made in rather traditional ways. We classify the products according to a few criteria that dominate the principle of their manufacturing process. Figure 14.1 gives an overview based on the main ingredients used (whole soybeans, crushed or pounded soybeans, mixtures of soybeans and cereal grains), the kind of fermentation starters used (bacteria, molds either as pure cultures or as mixed cultures obtained by natural enrichment), the use of salt or brine, and the physical consistency (liquid sauces, semisolid pastes, or whole beans). In each category one or more national names are mentioned (e.g., *chong-kukjang*). We refer to these names in the other sections, where we explain specific processes, microorganisms, and quality aspects.

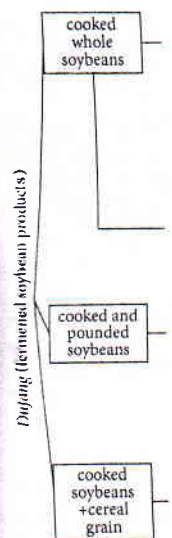


FIGURE 14.1 7  
(Lee 1990).

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