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PART V: FERMENTATIONS AND FOOD SCIENCE

BY

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AUTHOR'S NOTE

This book may be said to have had its genesis in two memorable events that I experienced in China more than fifty years ago. The first was an enforced holiday I had for several months in the fall of 1942 in my ancestral village, Hothang 鶴塘, and the second a delightful encounter in the spring of 1943 with the eminent scholar, Shih Shêng-Han 石聲漢. Hothang is a tiny village about seventy kilometres north of Foochow 福州. It seemed a world away from the bustling city of Hong Kong where I was a research student less than a year earlier. My comfortable life there was shattered when the Japanese suddenly attacked on the morning of 8 December 1941. After Hong Kong fell on Christmas day I was cut off from my family in Malaya and left without any means of support. I realised that the best thing for me to do was to leave for China as soon as possible. The opportunity came early in February, 1942, when I made my way, with the help of friends, through the New Territories and crossed the border into Free China. My original plan was to travel to Hothang to visit my paternal grandmother, but the plan encountered a delay along the way. I stopped by at Amoy University in Changting 長汀 to deliver a message to Professor Arthur Lee from his niece in Hong Kong who was a classmate of mine.[1] He kindly persuaded the University to offer me a job as an instructor in the Chemistry Department, which I gratefully accepted.

After the semester was over I continued my journey to Hothang, where I had a joyous reunion with my grandmother and other relatives. While in Changting I had met a couple of field officers of the Chinese Industrial Cooperatives (CIC) who indicated to me that they were in need of technical personnel in Szechuan and Kansu. I expressed my interest to serve in their organisation. In July I went to Foochow to visit the Anglican Bishop of Fukien, C. B. R. Sargent, who was the teacher of a close friend in Hong Kong.[2] When I returned to the village there was a letter from CIC headquarters asking me if I would be willing to accept an appointment as a research technician in Chengtu. I was delighted and replied that I would. I immediately resigned from Amoy University, fully expecting to be on my way to Szechuan within a couple of months. But the wheels of bureaucracy grinded ever so slowly. I waited and waited as months went by.

Hothang was a small village with probably no more than a couple of a hundred inhabitants. It had one narrow street paved with rectangular blocks of stone, flanked by hills on one side and a rivulet on the other. A series of steps down the street from my grandmother's house would lead to the market square in the centre

[1] Arthur Lee was a Chinese Australian who came to Amoy to teach English. He married one of his students and stayed on to be Professor of English at the University. I am deeply grateful to him and Mrs Lee for their hospitality during my stay in Changting.

[2] Before he was consecrated Bishop of Fukien, Christopher Sargent was the Headmaster of the Diocesan Boy's School in Hong Kong. Unfortunately, he died from pneumonic plague on 8 August 1943.

of the village. Going up the hill in the other direction lies the Ancestral Temple, a building in traditional style with elegant sloping roofs. The only other public building in the village was the Christian Church on the far side of the market square.

Having virtually nothing to do, I spent a great deal of time observing the numerous food processing and culinary activities involved in the preparation of the meals I ate everyday. The primary staple in the village was, of course, rice, coarse white rice and red rice. For breakfast, rice was boiled gently in plenty of water and allowed to simmer into a congee[3] in one of the two large woks that sat on the stove in the kitchen.[4] For lunch and dinner, rice was boiled and the semi-cooked grains steamed in a bamboo steamer.[5] The wash water was usually fed to the pigs. To go with the congee we had roasted peanuts, pickled vegetables, salted duck eggs, fermented soybeans, fermented beancurd, and as a special treat deep fried crullers (*yu thiao* 油條) when they were available from the market. The steamed rice would be accompanied by beancurd, salted fish of various kinds, salted or pickled vegetables, fresh leafy vegetables or beans, dried seaweeds, and, on rare occasions, bacon, sausages, eggs, pork, chicken or fish. Vegetables and meat were usually stir-fried with lard or peanut oil, flavoured with soy sauce, fish sauce, salt, rice wine, vinegar and sesame oil. We drank tea during the day, and occasionally wine in the evening.

For fresh produce we relied on what we could get daily in the market at the centre of the village, which served as a gathering place for the people of several neighbouring villages as well as Hothang. I remember stalls selling various kinds of vegetables, fruits, bean sprouts, peanuts, chickens and occasionally fish. The latter two would be sold live. Depending on the season, I might also find hawkers peddling soft beancurd custard (*tou fu hua* 豆腐花), malt syrup candy (*mai ya thang* 麥芽糖), deep fried crullers (*yu tsa kui* 油炸鬼), and pastries made of glutinous rice (*no mi kao* 糯米糕). Among the shops that lined the sides of the square, several were trading in food products such as rice, wheat flour, salt, loose brown sugar, oil, wine, vinegar, soy sauce, fish sauce and brown sugar blocks. Three were of particular interest to me: the butcher, the beancurd shop and the noodle maker. The butcher probably slaughtered a pig every day. Sections of the animal would be hung on hooks so that the customer could easily decide which part of the pig and how much of it he wanted. The parts in greatest demand were the tenderloin, spareribs, liver, brain and kidney. Occasionally, goat meat might also be on sale, but no beef was available during my stay.

I must have spent hours watching the processing of soybeans into curds which were then pressed into blocks of *tou fu*. The process was identical to that shown in the Eastern Han mural from Ta-hu-thing, Mi-hsien down to the shape of the rotary quern for grinding the beans and the square wooden press for pressing the curds.[6]

[3] The significance of congee in the origin of grain fermentations is discussed on p. 260.

[4] The traditional Chinese stove is described on p. 80, and shown in Figs. 26a,b. Quite often chunks of sweet potato would be cooked together with rice in the congee.

[5] For a description of the steamer cf. pp. 76–82 and Figs. 23, 24, 26, 29.

[6] The Eastern Han mural is described on pp. 86–7.

Most of the beancurds produced were sold as blocks of fresh *tou fu*. Portions were pressed further and salted as *tou-fu-kan* 豆腐干 (dried beancurd). In the summer some of the fresh curds would be mixed with brown sugar water and sold as a delicious soupy custard (*tou-fu-hua*). The butcher and the beancurd shop were the busiest places in the village. They were usually sold out by midday. The noodle maker, however, remained open until early evening. He kneaded his dough with a long rolling pin until it was a thin sheet about two feet wide and several feet long. The sheet would be folded into a block and then sliced with a big cleaver. The long filaments of sliced noodle (*chhieh mien* 切麵) were boiled, strained, cooled on a round mat and sold.[7] The shop also served as a mini-restaurant. I often indulged myself with an afternoon snack of stir-fried noodles, noodle soup and on rare occasions wonton and noodles.

There was another shop making wheat flour foods closer to our house. This one made very fine noodles, called *kua-mien* 掛麵 (hung noodle) that is still a specialty of Fukien. The dough is pulled into banks of fine threads and then hung on wooden racks in the open to dry. Poles with racks were installed on the vacant lot next to the shop. On fine days we would see a forest of hung noodles being dried between the racks.[8] It was quite an amazing sight. The dried noodles were folded into bunches, and sold. This same shop also made a bun called *kuang-ping* 光餅 (bright bun) unique to northern Fukien. It is round and has a hole in the middle. It looks and tastes just like a bagel, except that it is smaller. What seemed to me especially interesting is the oven used to bake it. It is simply a large urn enclosed in a large block of clay. Charcoal is burnt at the bottom and the pieces of dough baked on the side of the urn.[9] Considerable skill is needed to collect the bun as soon as it is baked so that it does not fall into the fire. This shop also made moon cakes for the Autumn Festival.

The two most engrossing food processing operations could be seen taking place right next door. The family ran a small workshop making wine from steamed rice with the aid of the red *ferment* (*hung chhü* 紅麴).[10] The *ferment* was purchased locally, and the rice was the same as that we ate for lunch or dinner. There were urns containing wine fermentations at varying stages of maturity. When ready the mash was placed in a cloth bag and pressed in a square box under a block of stone. The red liquid was allowed to settle and then decanted into little urns and sealed. There were two major uses for the red residual mash. It was a popular flavouring agent for cooking chicken, pork and fish. It imparted a brilliantly red colour and a delicious flavour to the food. It was also extensively used as a preservative and pickling agent for meat, fish and vegetables, such as Chinese cabbage, turnips and ginger.[11] The young ginger root pickled in this way was absolutely delectable.

[7] The making of sliced noodles is discussed on p. 484, and illustrated in Fig. 113.

[8] The drying of *kua mien* is shown in Fig. 112.

[9] This is an example of the tandoor oven, seen all across Central Asia from Iran to the West and Sinkiang to the East.

[10] The making of red *ferment* and red wine is discussed on pp. 192–202.

[11] The use of the red wine residues as a preservative is discussed on pp. 302, 411, 413.

Next to the 'winery' is another workshop which made fermented soybeans (*shih* 豉) and soy sauce (*shih yu* 豉油).[12] To prepare *shih* soybeans were boiled, steamed, cooled, mixed with a small amount of previously moulded beans, spread out in an urn and allowed to become mouldy. The moulded beans were then incubated in a minimal amount of brine until it became dark brown. The *shih* was used mainly as a relish for breakfast. To make soy sauce, the cooked beans were mixed with flour and allowed to become mouldy as before. They were then incubated with a liberal amount of brine, and this time, it was the liquid that was collected. The solids were practically all disintegrated. The residue was fed to the pigs. Both the wine and the soyfoods prepared were sold through local shops.

Up the hill just below the Ancestral Temple was a large building called the Tea Trade Centre (*chha hang* 茶行). In it were a series of stoves with large woks for stir-frying tea leaves. In the late 19th and early 20th century this region used to be a flourishing centre for producing black tea (in Chinese red tea or *hung chha* 紅茶) for export.[13] But the industry declined when India replaced China as the world's major producer of black tea. Now the Trade Centre just processed a small amount of green tea for local consumption. The most impressive piece of equipment there was a giant wedge press made out of a single large tea trunk.[14] It was being used to press oil from tea seeds.

Soon it was October. The rice plants in the fields were ready for harvest. I went out several times at dawn to the fields owned by the family to watch how the plants were cut, threshed, and the grains collected. They were carried back to the village, dried on large mats, decorticated in in a clay quern (*lung* 礱), and winnowed in a machine to separate the kernels from the chaff. The kernels were carried to a mill by a stream nearby and polished in a series of trip hammers powered by a large water wheel just like the one shown in the *Thien Kung Khai Wu* 天工開物.[15]

I was impressed by the ingenuity displayed in the processes I saw. It seemed to me they all had a rational, scientific basis. The cooking of the rice allowed the starch to swell and become easily digestible not only to humans but also to microorganisms. The kneading of the wheat flour dough generated gluten which endowed it with flexibility and plasticity. But I marvelled at the extent to which a piece of dough could be stretched lengthwise until it reached almost silken dimensions. The grinding of soybeans in water to form a milk-like emulsion was presumably a natural consequence of the properties of the proteins and fats in the bean. What intrigued me most were the fermentations of grains into wine and soybeans into soy sauce. They were rather complicated processes that required a high level of understanding and technical skill. What is the scientific basis of these processes? How did they come

[12] The preparation of fermented soybeans and soy sauce is treated on pp. 336–74. Soy sauce is called *shih yu* (sauce from fermented soybeans) in Fukien and Kuangtung but *chiang yu* (sauce from fermented soybean paste) in most parts of China.

[13] The origin of black tea, called red tea in Chinese, is discussed on pp. 541–9.

[14] The Chinese wedge press is discussed on pp. 441–51. Cf. also *SCC* Vol. IV, Pt 2, p. 206 and Fig. 463.

[15] *TKKW*, pp. 79–92. For a discussion of the machines cf. *SCC* Vol. IV, Pt 2, pp. 151–5; 176–95.

about? What were their origins? How long ago were they discovered? When I asked the people doing the work, the answer was always that they had been around a long time, or that they were the legacy of Shên Nung, the legendary ruler who discovered Agriculture and Medicine.

As it turned out, the answer to some of the questions came sooner than I would have thought possible. By mid-November I had received all the necessary travel documents and a travel advance from the CIC. My grandmother made me a batch of malt candy from barley (or wheat) malt and steamed rice as a going away present. I left Hothang in early December[16] and travelled through Fukien, Kiangsi, Kuangtung, Kuangsi, Kweichow and Szechuan, eventually reaching Chengtu in early February, 1943. But before I had a chance to settle down in my new position, I received a letter in April from Joseph Needham who had recently arrived from England and was setting up a Sino-British Science Cooperation Office in Chungking, asking me if I would be interested in joining his organisation as his secretary and interpreter. After suitable negotiations with the CIC I was hired as his secretary in May and we started on our first peregrination together. From Chengtu we drove to Loshan 樂山 where our host was Wuhan University. There we met Shih Shêng-Han 石聲漢, Professor of Plant Physiology, who had ingeniously built all kinds of apparatus out of the simplest materials available both for research and teaching purposes.

After a week in Loshan we went on to Wu-tung-chhiao 五通橋, the centre of a chemical industry complex where we visited the Huang Hai 黃海 Research Laboratory, which had a programme on improving the strains of fungi used in the saccharification of grains for conversion to alcohol. It was there that I had my first view, under a microscope, of the myceliae of *Aspergillus* species isolated from the Chinese *ferment* (*chhü* 麴). Our next stop was Lichuang 李莊 which could only be reached by boat. We were to sail first on a salt transport boat down the river to Iping 宜賓, and then by steamer to Lichuang. To ensure that there would be no hitch, Shih Shêng-Han decided to come along as our guide. It turned out that his presence was invaluable, since the salt boat developed unexpected trouble after the very first day. Shih negotiated with the owner of a small boat, and we hired him to take us to Iping. But we missed the steamer there and continued the trip in the small boat all the way Lichuang.[17]

[16] I did not see Hotang again until January 1996, fifty-five years later. To my amazement it has become a bustling little town with several paved streets, motor vehicles moving to and fro, multistorey houses built of concrete and electric lights in the buildings. Our ancestral house where I stayed in 1942 still stands. It happens to be located in the small section of the old street that has been marked for preservation. The Ancestral Temple remains in good condition. It now doubles as a nursery school and kindergarten. The old Tea Trade Centre has been torn down. The picturesque mill with its huge water wheel has been dismantled. A new town hall stands on the site of the old Christian Church, which has been rebuilt on a location outside of town. The most striking impression I got during my brief visit is that everyone I met (which means practically everyone younger than I) spoke very good Mandarin (at least compared to me), whereas in 1942 few people spoke any Mandarin at all. Coupled with my experience in Taiwan, it is clear that there the search for a common spoken language for all China has been successfully supported by both the Communists in China and the Nationalists in Taiwan, cf. Ramsey, S. Robert (1987).

[17] For details of our boat trip see H. T. Huang (1982), pp. 44–6.

Shih Shêng-Han had received his doctorate from the Imperial College, London and spoke English fluently. He had a wry sense of humour and soon he and Needham were exchanging jokes in English. Conversation flowed easily amd continuously during the two days that we were together cooped up in a small space. We talked about all sorts of things but the topic that received the most attention was the History of Science and Technology in China. Shih seemed to be a fountain of information on the origin of the traditional agricultural and food processing technologies of China. I quickly seized the opportunity and plied him with questions on the science and the history of the food processes that I had seen and pondered on in Hotang half a year ago. I learned that, indeed, many of them had had a long history. In fact, detailed descriptions about most of them can be found in a +6th century compendium called the *Chhi Min Yao Shu* 齊民要術 (Important Arts for the People's Welfare).

Shih Shêng-Han stayed on with us in Lichuang for two days. He and I shared a bedroom in the guest house of Tungchi 同濟 University. Our conversations on traditional Chinese food processing continued deep into the night. He patiently answered all my questions. By then I had learned that he was not only a competent scientist, a noted scholar of Chinese classics but also a renowned calligrapher.[18] Obligingly he wrote down the two poems he had introduced us to during our memorable boat trip on two small scrolls, which I later mounted and framed. They have adorned my study for many years and remained a constant source of inspiration as I laboured in the myriad tasks involved in the writing of this book.

Now, as I look back across a span of half a century, I realise how fortunate I was to have been a principal participant in these memorable events which have in recent years assumed a renewed importance as I laboured to complete the present volume. For my sojourn in Hothang enabled me to witness the practice of traditional Chinese food processing methods in the context of daily living in a small village before the onslaught of modern technology. And my encounter with Shih Shêng-Han gave me an opportunity to discuss the scientific basis and historical background of this technology with a foremost scholar of the field. It was the memory of these events at the back of my mind[19] that encouraged me to accept, with little hesitation, Joseph Needham's invitation in late 1984 to be the collaborator responsible for the writing of Section 40, Biochemical Technology, of his *Science and Civilisation in China* (*SCC*) series.

As Needham reiterated in his invitation, the focus of this Section should be the scientific basis and historical background of the fermentations and food processing

[18] An example of Shih's calligraphy still hangs in the Needham Research Institute, Cambridge.

[19] Actually, the memories of those two events were never too deeply buried at the back of my mind. I spent many years in my professional life as a research scientist and research administrator in the fermentation and food industry in the US. I was familiar with the production and application of fungal enzymes used in food processing in the US including amylases, proteases, pectinases, lipases and microbial rennet. What is not generally known is that most of the organisms involved, such as *Aspergillus*, *Rhizopus* and *Mucor* species, were first isolated from the ancient *ferment* 麴 (Chinese *chhü* or Japanese *koji*), the principal agent used in Chinese and Japanese fermentation processes.

technologies that are the mainstay of the Chinese dietary system. Although much has been written about Chinese cuisine and food culture, very little has been written by European scholars on the technology of Chinese processed foods. As a result, the translation of Chinese food terms into English is often highly misleading.[20] He hoped also, that along the way, we would be able to satisfy his personal curiosity about the origin and development of a number of unusual food products that he had encountered during his travels in China in the early 1940s, such as the red *ferment* that colours chicken and fish a brilliant red in Foochow, the *fu ju* (fermented bean curd) that endows the Buddhist's vegetarian stew with a unique flavour in Kuangtung, the delectable aroma of the distilled wine in Kweichow, the soy milk that we consumed every morning at breakfast in the Northwest, and the 'cream' that made possible the delicious 'creamed cauliflower 奶油菜花' that soothed our spirit as we struggled with endless calamities suffered by our truck along the panhandle in Kansu.

As originally conceived in the master-plan for *SCC* published in 1954,[21] and revised in 1979, Section 40 was to consist of one major subject, Fermentation (i.e. the conversion of grains to alcoholic drinks), and two minor ones, Food Technology (i.e. the production of processed foods from soybeans and grains), and Nutrition (with emphasis on nutritional deficiency diseases). Two revisions of the plan were discussed and adopted in the first few years after I started to work on the project. Firstly, Food Technology was greatly expanded since it became clear, based on the wealth of material that Needham and Lu Gwei-Djen had already collected, the space allotted to this subject in 1979 was woefully inadequate. Secondly, processing and utilisation of tea were transferred from Section 42 into this Section.[22] After all, tea and wine are the two principal beverages of the Chinese dietary system; thus the processing of tea should be discussed in the company of the technology of wine. Additional adjustments and revisions proved to be necessary in response to the recommendations of anonymous readers who evaluated the preliminary draft on behalf of the Publications Board of the Needham Research Institute. As it turns out, the book that finally emerges is an enlargement of the 1954 master-plan, that is to say, it contains a major section on Fermentations and a minor section on Nutrition, except that another major section, that on Food Science is added.

The book covers almost all aspects of the traditional food processing technologies that I had witnessed in 1942. It also includes the processing of foods that I had encountered as part of my diet in Hothang, but that were not produced

[20] A sentiment shared by David Knechtges (1986), p. 63, who points out that 'exacting philology and careful science' are needed to render a Chinese food term into English.

[21] See *Science and Civilisation in China* (*SCC* hereafter) Vol. 1 (1954), pp. xxxv–xxxvi. This plan was revised in the report on *Status of the Project*, (1979), Cambridge University Press, p. 32.

[22] Tea was originally a topic in Section 42, Agro-Industries, which was the responsibility of Christian Daniels. Under the reorganisation Tea was split into two parts. Processing and utilisation became a chapter in this work. Horticulture and genetics were assigned to the Section 38 as a continuation of the volume on Botany, which is being prepared by Georges Metailie. I regret the inconvenience this must have caused Professor Daniels, whose excellent contribution to Section 42 was published in 1996.

locally. These were imported from neighbouring counties, for example, fish sauce, pickled fish, salted fish, salted pork and cured meat products. As I began the project I was excited by the prospect of rediscovering or refining answers to the many questions on Chinese processed foods that I had asked myself years ago and which were reiterated by Joseph Needham. How did they come about? What were their origins? What are the scientific bases of the technologies? How do they compare with processed foods developed in the West? But new questions had already entered my mind even before the work began. To what extent were Chinese processed foods transmitted to her neighbours? Did Chinese food technology have any influence on the development of the food systems of the West? What are the nutritional value of the processed foods? What is the nutritional efficacy of a traditional Chinese diet?

To provide an adequate background for the consideration of these questions, the book begins, in the Introduction, with a survey of the food resources in ancient China, and an account of how the food materials were prepared, cooked and presented for consumption. This is followed by a review of the Literature and Sources used in this study. From there we begin our exploration of traditional Chinese food processing technology. Our first topic is Fermentation technology, the production of alcoholic drinks in their various manifestations, wines from grains, red wine, distilled wine, medicated wines, and wines from fruits, honey and milk. Included also is a comparison of the very different technologies for converting grains into alcoholic drinks in East Asia and in the West, and an explanation of the reason for this divergence. The account ends with the production of vinegar from wine. In the next topic, we go on to the processes by which soybeans are converted by biological, physical, chemical or microbial methods into palatable and nutritious food products. Perhaps the most striking impression one gets from these accounts is the remarkable role a culture of common grain moulds, of the families *Aspergillus*, *Rhizopus* and *Mucor*, known as *chhü* 麴 has played in the processing of foods in China, a situation without parallel among the food cultures of the world. The influence of the grain moulds is seen even in the next chapter when we consider various technologies for the Processing and Preservation of a variety of foodstuffs, such as the making of pickled meat and vegetables, fermented fish sauces, salted fish and meat, fruit preserves, vegetable oil, malt sugar, starch, noodles and other pasta foods, gluten and the use of cold storage in food preservation. In some of the examples, the role of the grain moulds is augmented by the activity of lactic acid bacteria, which are, of course, well known in the food technology of the West. The next topic is the processing of tea, which has undergone a series of changes since it was first prepared as a drink before or during the Han Dynasty. What came as a complete surprise is the discovery that the tea most widely consumed today, i.e. fully fermented tea, known as 'black tea' in the West but 'red tea' (*hung chha* 紅茶) in China, did not exist until about 1840. What was called 'black tea' in maritime trade by tea merchants of the East India Company from about +1720 to 1840 was actually a partly fermented or *oolong* tea. The discussion on tea ends with a consideration of the

effects of tea drinking on health as understood by the Chinese, some of which have turned out to be quite acceptable on the basis of modern scientific studies. The chapter on Nutrition is focussed on the natural history of nutritional deficiency diseases in China and how they were treated by dietary means. The volume concludes with a number of Reflections on the overall process of discovery, development and utilisation in food technology in China, its failures as well as its triumphs, and how the grain moulds have surreptitiously crept their way into the technology used today in the manufacture of many familiar processed foods seen on modern grocery shelves around the world.

Thus, in a nutshell, this work deals mainly with developments in Fermentations and Food Science with a brief foray into Nutrition during the historical period in China from antiquity to the 19th century. A great deal of information is available in the classical and mediaeval literature, although much of it is widely scattered and not easily accessible. But for two issues which Needham had raised in our discussions, I have had to explore developments far back into the prehistoric past. For these I had no choice but to rely entirely on the archaeological record which has shifted significantly through new finds even during the span of time that this work was undergoing preparation. The first is the fermentation of cereal grains into alcoholic drinks, East and West. Why did the Chinese replace sprouted grains by a culture of grain moulds as the saccharifying agent in the conversion of grains to sugar? Why did the West fail to discover the bountiful saccharifying activity of the grain moulds? It is impossible to discuss this issue without considering how grains were processed in China and the West, respectively, in the early Neolithic age at the dawn of the agricultural revolution. The second is why milk and milk products did not became a staple part of the diet in China even though dairy animals were reared by the Neolithic Chinese? It is impossible to discuss this problem without going back to the early stage of animal domestication and the origin of a nomadic pastoral way of life, West and East. Although I have included an answer for only the first of the two issues in this work, the forays into the distant past have reinforced the notion that many of our cherished dietary practices, habits and attitudes may have had a longer history than is generally recognised.

This volume is dedicated to the memory of three pioneers in the study of Chinese food science, culture and nutrition. My debt to Shih Shêng-Han needs no reiteration. It is my misfortune that I never had a chance to meet Shinoda Osamu 筱田統 while he was alive. The depth and breadth of his scholarship and the freshness of his ideas never failed to impress me as I delved into his wide-ranging contributions to the field. A translation of a collection of his essays, under the title, *Chung-kuo shih-wu shih yen-chiu* 中國食物史研究 (Studies on the History of Chinese Foods), has been a constant companion soon after it was published. I sorely missed the support and counsel of Lu Gwei-Djen that I had enjoyed during the last few years of her life. She took great pains to give me useful answers to the many questions I had put to her, and continued to feed me material that she thought would be of interest for this Section even in the last few months before she passed away.

Many friends and colleagues have contributed to the substance of the present volume. Those who have read parts of it in draft form and provided comments and advice and steered me to publications that I had missed are listed at the end of this note. But I do need to single out for special thanks several colleagues from this list who have put in a large amount of time and effort to help me in this endeavour. The late Wu Te-To 吳德鐸 of Shanghai went out of his way to provide me with a valuable array of pertinent publications from China, including all the newly annotated editions of the classics of food literature published in the last two decades by Commerce Publishers, Peking. From 1984 to his untimely death in 1992 we had exchanged a steady stream of letters on many issues, including the origin of distilled wine, relevant to the content of this volume. Ishige Naomichi 石毛直道 of Osaka generously sent me many of his books and publications on food culture and technology in East Asia as well as reprints of articles from the Shinoda Collection at the National Museum of Ethnology. He was my principal source of information and advice on fermented fish products and filamentous noodles. He graciously answered all my questions, some of which must have required a considerable amount of his time. William Shurtleff of Lafayette, California, was my principal consultant on the processing of soybeans. He has collected probably the world's largest data base on soyfoods, and was ever ready to search through it for information I needed. Many useful publications were the gift of Hung Kuang-Chu 洪光注 of Peking and Françoise Sabban of Paris. Finally, E. N. Anderson of Riverside, California, kindly read through the entire draft with a fine toothcomb, and offered hundreds of ameliorations and corrections.

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Although I searched for establishments that still practice the art of food processing with traditional equipment during my travels in China in the 1980s and 90s, I was unsuccessful in locating any of them in the cities I visited. The best I could find were factories that follow traditional processing methods but carry them out with modern equipment. These I visited with pleasure and profit. They include:

Shanghai Fermentation Plant No. 6 上海釀造六廠
Soy sauce and soy paste
Shanghai Chinese Wine Fermentation Factory 上海中國釀酒廠
Rice wines, fruit wines, distilled wines
Chiang-nan Beer Factory, Shanghai 江南啤酒廠
Beer, (Brick Ferment), distilled wine
Tou fu Production Workshop, at the Fukien Agricultural University, Foochow
Tou fu is made fresh everyday
Foochow Winery No. 1 福州第一酒廠
Yellow wine, using the red *ferment*
Foochow Fermentation Plant 福州釀造廠
Soy sauce and soy paste, fish sauce
Ku-thien Red *Ferment* Production Plant 古田紅麴廠
Red *Ferment*, supplied to all manufacturers in Fukien

My thanks go to Wu Te-To for arranging all the visits in Shanghai, to Chen Jiahua for the *tou fu* workshop and Foochow Winery No. 1, and to Chen Jiahua and Rao Pingfan for the Fermentation Plant in Foochow and the Red *ferment* plant in Ku-thien and to the personnel of these facilities who patiently explained to me the details of the processes every step of the way. These visits have enhanced my understanding of how the efficiency of the traditional processes have been increased by the application of modern science and technology. In this connection I wish also to thank Chen Wenhua for organising the memorable trip we took together to Ta-huting, Mi-hsien to see the remarkable Eastern Han wall mural which describes the preparation of *tou fu* in great detail.

When this project began in 1985 I was a Program Director for Biochemistry at the National Science Foundation (NSF), Washington, DC. I spent all the time I could spare on it, in the evenings, on weekends and on holidays, as well as 10 per cent of my official time on weekdays with the blessing of the Foundation. In 1988 I received a six month sabbatical for the project. I wish to take this opportunity to

thank the NSF for the support I enjoyed until my retirement in 1990. Progress should have been much faster after my retirement, but a new obligation intervened. From 1990 to 1994 I served as a part-time Deputy Director of the Needham Research Institute in Cambridge. While it allowed me to take advantage of the facilities of the Library there, it also meant that a great deal of my time was diverted away from the writing of this book, and progress remained slow. It was not until the end of 1995 that a preliminary draft of the whole work was completed. Unfortunately, in early 1996 disaster struck. I had to undergo open heart surgery which effectively incapacitated me for more than four months. But fortunately, my recovery was uneventful and soon I was able to continue with the work. It is, therefore, with a profound sense of joy and relief that I realise the project, which has dominated my life for more than ten years, is at long last drawing to a close.

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[23] Deceased, 24 March 1995.

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While their advice and counsel have been invaluable, I alone am responsible for any deficiencies and errors that remain in the text.[25]

Finally, my deepest gratitude goes to the late Joseph Needham, who gave me the inspiration and encouragement to embark on this adventure, and to my wife Rita, whose loving care and constant support have helped to make it come true.

H. T. Huang
Alexandria, VA

[24] Deceased, 29 February 1992.
[25] Unless stated otherwise, all English versions of Chinese passages cited in the text are translated by me; I alone am responsible for any errors in the translations.