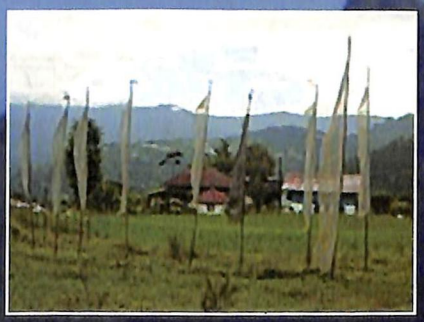
HIMALAYAN FERMENTED FOODS

Microbiology, Nutrition, and Ethnic Values



Jyoti Prakash Tamang

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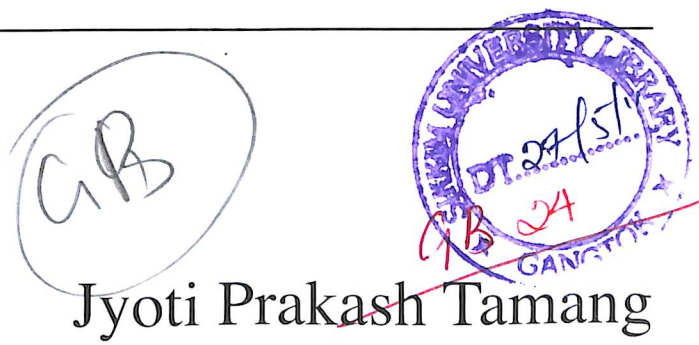

Jyoti Prakash Tamang

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Contents

Preface

The Himalayan region comprises a diversity of hot spots with rich bioresources of flora and fauna. The Himalayas are also a sacred place for millions of Buddhist and Hindu ethnic people. The approximate population of the Himalayas has been estimated at more than 65 million, with more than 300 major ethnic groups. This mix of ancient cultures, ethnic diversity, and biological resources has produced a remarkably diverse food culture, comprising a range of fermented and nonfermented ethnic foods and alcoholic beverages.

Food symbolizes the culture of a community, providing information reflecting its eating habits, consumption patterns, food preferences, nutritional security and community health, agricultural and livestock systems, marketing strategies, socioeconomy, ethnicity, and religious taboos. More than 150 different types of ethnic fermented foods and alcoholic beverages are prepared and consumed by the Himalayan people, which include milk, vegetable, bamboo, soybean, meat, fish, cereal, and alcoholic beverages. The food culture of the Himalayas is a unique fusion of the soybean–alcohol-consuming Chinese culture from the north and the milk–vegetable eating Hindu culture from the south.

Diverse microorganisms, ranging from mycelial fungi to enzyme- and alcohol-producing yeasts and bacteria, are associated with the fermentation and production of ethnic Himalayan foods and alcoholic drinks. Most of the foods are fermented naturally, except for the alcoholic beverages, which are produced by using a consortium of microorganisms in the form of dry, cereal-based starter materials. Diversity within the species of lactic acid bacteria and bacilli has created ethnic foods with different sensory characteristics. The functional microorganisms present in the Himalayan-fermented foods have many biological functions that provide a number of important benefits, including health-promoting benefits, biopreservation of perishable foods, bioenrichment of nutritional value, protective properties, and therapeutic values.

Himalayan fermented foods comprise all types of available substrates, ranging from milk to alcohol, soybeans to cereals, vegetables to bamboo, meat to fish, and alcoholic beverages to nonalcoholic beverages.

The historical record of consumption of milk and milk products in Nepal in 900 b.c. throws light on the cultural history of food habits of the Himalayan people. Although the diversity of the Himalayan foods is unknown to most of the countries outside the Himalayas, these ethnic foods have been consumed by the Himalayan people for more than 2500 years.

This book has ten chapters covering the indigenous methods of preparation, culinary practices, socioeconomic impacts, microbiology, functional properties, nutritional values, antiquity, and ethnic values of Himalayan fermented foods. I have tried to document and update the information on the indigenous knowledge of production methods, history (antiquity), and ethnic values based on field surveys and relevant historical documents. The microbiological, biochemical, nutritional, and functional aspects are mostly based on our primary research works. Perhaps, I am one of the few scholars to research works on Himalayan fermented foods for more than two decades. Today, there are many universities and research institutes in India and abroad working on different aspects of fermented foods and beverages, including the Himalayas. Some of the researchers are my students.

I am grateful to Taylor and Francis Group for publishing this book. I hope it will be referenced by researchers, students, teachers, tourists, travelers, media persons, food entrepreneurs, agriculturalists, government policy makers, anthropologists, ethnologists, and sociologists who have an interest in the Himalayas and their people and bioresources. There are many books that address the myriad issues and aspects of the Himalayas, but a book that specifically describes the Himalayan foods and food culture is rare. This book, *Himalayan Fermented Foods: Microbiology, Nutrition, and Ethnic Values*, published by Taylor and Francis Group, is a beginning.

I salute my ancestors for providing a rich diversity of ethnic fermented foods and drinks and for maintaining the unknown microbial genetic resources with vast bionutrients and health-promoting benefits.

Jyoti Prakash Tamang
Darjeeling, India

Acknowledgments

I am thankful to my wife Dr. Namrata Thapa for constant support and technical assistance in the preparation of this book. Over the past 16 years, the team of brilliant Ph.D. students that I have recruited from the Food Microbiology Laboratory, Sikkim Government College, Gangtok, has been the real driving force in researching and identifying the scientific mechanisms of ethnic Himalayan fermented foods. I express my deepest appreciation to all my former students. Some of them are placed in good jobs elsewhere, and some are present students. The list includes Dr. Saroj Thapa, Dr. Sailendra Dewan, Dr. Hannah Yonzan, Dr. Buddhiman Tamang, Dr. Arun Rai, Mr. Rajen Chettri, Ms. Nikki Kharel, Mr. Bimal Rai, Mr. Sudhan Pradhan, Mr. Rudra Mani Sharma, Ms. Jayasree Charkraborty, and many others. I am also grateful for the efforts of the supporting staff and Mr. Karma Tamang. My sincere thanks to Mr. Satyam Thapa and Mr. Ravi for assisting me in the computations presented in this book. My special thanks to the following researchers for helping me in preparation of this book: Dr. Diwakar Pradhan of Banaras Hindu University; Dr. Vimal Khawas of Sikkim University; Dr. Toshirou Nagai of the Institute of Agrobiological Sciences, Tsukuba; Dr. A. A. Mao of the Botanical Survey of India; Mr. J. R. Subba of Gangtok; Mr. Bejay Chettri of Deokota Sangh, Siliguri; and Mr. H. K. Pradhan of Siliguri.

My sincere thanks to the various cultural associations, societies, and individuals of Darjeeling hills, Sikkim, Nepal, Bhutan, Uttarakhand, Himachal Pradesh, Jammu and Kashmir, and all North East Indian states for their cooperation in compilation of the food habits of the communities, and also to all Himalayan ethnic people, to which I belong.

I have been inspired by my beloved father (Aapa), the late Capt. Surjaman Tamang; my mother (Aama), Mrs. Prava Devi Tamang; and my father-in-law (Baba), the late Bhuwan Singh Thapa. I dedicate this book to all of them. My daughter Ashweela and my son Ashwaath missed the vacation due to my preoccupation with this book, but they realized the importance of this book and supported me. My love to them and to Namrata.

I am grateful to Taylor and Francis Group for offering me the opportunity to write this book, particularly Dr. Stephen Zollo, Ms. Jennifer Ahringer, and Ms. Gail Renard.

Jyoti Prakash Tamang

About the Author

Dr. Jyoti Prakash Tamang, a leading authority in food microbiology, has been studying the Himalayan fermented foods and beverages concerning microbiology, nutritional aspects, functionalities, and food cultures for the last 22 years. He earned a B.Sc. (honors), M.Sc., and Ph.D. from North Bengal University, followed by post-doctoral research at the National Food Research Institute (Japan) and the Institute of Hygiene and Toxicology (Germany). Dr. Tamang was awarded the Gold Medal by North Bengal University in 1985, the National Bioscience Award of Department of Biotechnology of Ministry of Science and Technology of India in 2005, and became a Fellow of the Biotech Research Society of India in 2006.

Dr. Tramang has published more than 75 research papers in peer-reviewed international and national journals, has filed a patent, and is guiding several students. He has presented his works in 17 different countries and is a member of several prestigious national and international academic and scientific organizations. He is a chief editor of *Journal of Hill Research*, and he is a regular reviewer of many reputable national and international scientific journals and books. Professor Tamang is the president of the Centre for Traditional Food Research at Darjeeling, a team leader of the Food Microbiology Laboratory, and a senior visiting faculty in microbiology at Sikkim Central University.

chapter one

The Himalayas and food culture

1.1 The Himalayas

The great Himalayas are a sacred place for millions of Buddhist and Hindu people and the center of a rich diversity of cultures and biological resources. The meaning of the word *Himalayas* in Sanskrit is "abode of snow." The Himalayan arc extends between latitudes 26°20′ and 35°40′ north and between longitudes 74°50′ and 95°40′ east (Ives 2006). The Himalayas extend from the Indus Trench below Nanga Parbat (8125 m) in the west to the Yarlungtsangpo-Brahmaputra gorge below Namche Barwa (7756 m) in the east—a west–northwest to east–southeast distance of about 2500 km and a width of 200–300 km—and include India (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Darjeeling hills, Arunachal Pradesh, and some hill regions of northern Assam), Nepal, Bhutan, and Tibet Autonomous Region in China. The region directly provides a life-support base for over 65 million mountain people (Khawas 2008). The Himalayas form the highest mountain region in the world with more than 30 peaks, and one of them is Mount Everest (8848 m), the highest mountain in the world. Mount Kangchendzonga (8579 m), the third-highest peak in the world, is India's highest mountain peak and rises from Sikkim.

Geographically, the Himalayan mountain system is divided into (a) the Greater Himalaya Himadri area above the main central thrust, consisting of snow-clad peaks, glaciers, and ranges of mountains, (b) the Lesser Himalaya Himachal, which is separated from the Himadri by the main central thrust in the north and by the main boundary thrust in the south, consisting of high mountains cut into deep ravines and precipitous defiles, and (c) the sub-Himalayan tract Sivalik, the foothill belts of the region, consisting of the latest geological formation of loose boulders and soil (Pradhan et al. 2004).

The Himalayas are categorized into the following divisions based on population and vegetation: western Himalayas (Jammu & Kashmir, Himachal Pradesh), central Himalayas (Uttarakhand, western Nepal), and eastern Himalayas (eastern Nepal, Darjeeling hills, Sikkim, Arunachal Pradesh, hills of North East India, Bhutan, and Tibet Autonomous Region in China).

The geographical locations of the Indian Himalayas have been described by Nandy et al. (2006). The Kashmir Himalayas occupy the geographical location between latitudes 32°17′–37°5′ north and longitudes 72°40′–80°30′ east, with a total area of 222,236 km^2. Kashmir has borders with Afghanistan in the northwest, with Pakistan in the west, and with China in the north. The whole region is differentiated into four broad groups—Karakoram, Ladakh, Zaskar, and Pir Panjal—and these mountain ranges are separated by deep gorges, forming the valleys of the Shyok, Indus, and Jhelum rivers, respectively. The Himachal Himalayas lie between the latitudes 30°23′–33°13′ north and longitudes 75°43′–79°4′ east, with a total area covering 55,673 km^2. The state of Himachal Pradesh lies to the south of Jammu & Kashmir state. The state is bound in the east by China, the Garhwal region of Uttarakhand state in the southeast, Punjab state in the southwest, and in the south by Haryana state. The Uttarakhand Himalayas are geographically located between latitudes 29°5′–31°25′ north and longitudes 77°45′–81° east, covering an area of 51,124 km^2. The region comprises two administrative units of Uttarakhand state, i.e., Garhwal (northwest) and Kumaun (southeast). The eastern Himalayan region lies between the latitudes 26°40′–29°30′ north and longitudes 88°5′–97°5′ east and covers a total area of 93,988 km^2, comprising Darjeeling hills, Sikkim, and Arunachal Pradesh. Bhutan is located between the Tibetan plateau and Assam-North Bengal plains of India, and has borders with Sikkim in the west, China (Tibetan Autonomous Region) in the north, and Arunachal Pradesh in the west. The Purvanchal Himalayas lie between the latitudes 21°5′–28°23′ north and longitudes 91°13′–97°25′ east, covering a total area of 108, 229 km^2, comprising the hills of Assam (15,322 km^2), Manipur (22,327 km^2), Meghalaya (22,429 km^2), Mizoram (21,081 km^2), Nagaland (16,579 km^2), and Tripura (10,491 km^2). The region of North East India has international boundaries in the east with Myanmar, in the south and west with Bangladesh, in the northwest with Bhutan, and in the north with Tibet Autonomous Region of China.

1.2 *Agriculture in the Himalayas*

The agroclimatic conditions of the Himalayas vary from hot, subhumid tropical in the southern low tracts to temperate, cold alpine, and glacial in the northern high mountains, due to their various subecological locations, elevation, and topography. The temperature varies from the lowest recorded temperature in Leh in the Ladakh region of Jammu & Kashmir in India at −28.3°C and the highest recorded temperature in Jammu in Jammu & Kashmir state of India at 47.2°C (Singh 1991).

The lower valleys and gorges are very dry, and local agriculture production depends upon snowmelt and glacial-melt irrigation, commonly called *kuhl* in Himachal Pradesh (Ives and Messerli 1989). Natural

vegetation belts range from tropical monsoon rain forest or *sal* forest (*Shorea robusta*) in the south, through a series of forest belts, to the upper timberline at approximately 4000–4500 m (Ives and Messerli 1989). Above this, the *Rhododendron*-shrub belt gives out onto alpine meadows, a subrival belt of extensive bare ground and scattered shrubs, herbs, bryophytes, pteridophytes, and lichens, and finally at 5000–5500 m, permanent ice and snow with steep rock outcrops (Samant and Dhar 1997).

The ethnic people of North East India, mainly Nagaland, have adopted the traditional practice of *jhum* cultivation, wherein land is cleared of its natural vegetation and farmed until it can no longer sustain production, at which point it is abandoned and left to regenerate itself with natural vegetation (Barthakur 1981). As an agricultural system, *jhum* cultivation has the disadvantage of deteriorating ecological balances and accelerating soil erosion; however, the *jhum* system is also productive and sustainable, with multiple intercropping of up to 60 food crops in one field (Barthakur 1981).

Agriculture and livestock are the major livelihood in the Himalayas, where the ethnic people have traditionally practiced integrated agriculture, animal husbandry, agro-forestry, and forestry. Over 85% of the population is directly or indirectly dependent on agriculture for its livelihood (Khawas 2008). Mountain geography and inaccessibility due to difficult terrain and lack of infrastructure have compelled the people to adopt the agro-biodiversity system, although commercial agriculture is not as high yielding and profitable as in the plains areas (Nandy and Samal 2005). Forest coverage in the Indian Himalayas is over 52% of the total reported area, followed by wastelands and agricultural land (Nandy et al. 2006).

The varied topographic and agroclimatic conditions permit the cultivation of a wide variety of indigenous crops and fruits, ranging from subtropical to cool temperate. The Himalaya region has been a rich genetic source of many indigenous varieties of agricultural plants: cereals such as rice, maize, finger millet, wheat, buckwheat, barley, sorghum, pearl millet; pulses such as soybeans, black gram, green gram, garden peas, black lentils, French beans; vegetables such as cabbage, cauliflower, leafy mustard (*rayo sag*), young tendrils and fruits and tubers of squash (*iskus*), brinjal, chilli, cucumber, young tendrils and fruits of pumpkin, sponge gourd, tomato, tree tomato, lemon, etc.; tubers and rhizomes such as potato, beetroot, sweet potato, cassava, arum/taro, yam, ginger, turmeric, large cardamom; and roots such as radish, carrot, etc. A wide variety of seasonal fruits such as orange, apple, mango, papaya, guava, banana, pear, peach, fig, avocado, etc., are also cultivated and consumed (Annual Progress Report 2005; Nandy and Samal 2005).

Tea, ginger, large cardamom, garlic, medicinal and aromatic plants, wild and domesticated ornamental plants, and orchids are the cash generators for the people. Bee-farming (both domestic and wild bees) for honey is also a common practice among the Himalayan farmers. Some indigenous

varieties of chilli—locally called *dalley khorsani* (round red/green chilli) of Darjeeling hills, Sikkim, and Nepal; *uamorok* of Manipur; and *raja* of Nagaland—are among the hottest chillies in the world and are promising agricultural products in the Himalayan regions. Varieties of wild edible plants, including young bamboo shoots, ferns, stinging nettles, and their parts such as seeds, fruits, roots, leaves, and flowers are part of the local diet eaten by the Himalayan people (Sundriyal and Rai 1996; Sundriyal and Sundriyal 2004; Rai et al. 2005).

More than 78 indigenous and exotic species of bamboo belonging to 19 genera are found in the biodiversity-rich regions of North East India (Hore 1998). About 26.2 tons, 435 tons, and 426.8 tons of bamboo shoots are harvested annually in Sikkim, Meghalaya, and Mizoram states, respectively, located in the North East region of India (Bhatt et al. 2003).

Due to the predominant agrarian economy in the Himalayas, animal husbandry plays a vital role for supporting agricultural operations to supplement food and as sources of manure. The domestic livestock of the Himalayas includes cow, ox, goat, pig, sheep, yak, joe/churru (hybrid of cow and yak), buffalo, poultry, etc., which are mainly used for meat, milk and milk products, and eggs. Yaks (*Bos grunniens*) are reared mostly on extensive alpine and subalpine scrublands between 2100 and 4500 m in altitude for milk products, meat, hairs, tails, and skins (Pal et al. 1995; Balaraman and Golay 1991; Sharma et al. 2006).

The river systems along with their tributaries in the Himalayas exhibit a wide range of gradients from subtropical to alpine zone. Many indigenous species of fish are found in the rivers of Sikkim and Darjeeling hills (Thapa 2002). The Brahmaputra and its tributary rivers in Assam and Arunachal Pradesh consist of more than 126 species of fish belonging to 26 families (Motwani et al. 1962; Jhingran 1977). Logtak lake in Manipur, which provides the main fishery resources in Manipur and other adjoining states, has varieties of ichthyofauna mostly dominated by species of *Puntius, Channa, Anabas*, etc. (Chaudhuri and Banerjee 1965). The people of North East India catch the available fish from various sources, mainly from rivers, streams, and lakes, and consume fresh as well as traditionally processed fish products (Thapa et al. 2006). Inland fishery programs in the lower altitudes of some of the Himalayan regions are becoming popular among farmers as a source of income.

1.3 *Ethnic people*

The Hindu epics in the history of India identify the original inhabitants of the Himalayas as the Kinnar, Kilind, and Kirat (O'Flaherty 1975; Ives and Messerli 1989). The Negroids, the Mongoloids, and the Aryans form the macro social groups of the Himalayan population (Ives and Messerli 1989; Khawas 2008).

The Hindus of Indian origin mainly dominate the sub-Himalayan and middle Himalayan valleys, while the Great Himalayan region is influenced by the Tibetan Buddhists (Khawas 2008). The ethnicity of the Gilgit, Baltistan, and Poonch regions of Kashmir are overwhelmingly Muslim; Jammu is mainly Hindu; and Ladakh is predominantly Buddhist (Tibeto-Mongoloids). The semiarid highland zone of Himachal Pradesh, the trans-Himalayan tracts of Lahaul-Spiti and Kinnaur, are inhabited by Tibetans, while the other parts of Himachal Pradesh are mainly inhabited by the Hindus. Culturally, Uttarakhand is largely dominated by the Hindu Kumauni and the Garhwali culture in the middle and low altitudes, while in the northern high-altitude valleys, the Bhotia or Bhutia of the Tibetan origin predominates. Nepal has a blend of both Hindu and Buddhist cultures, producing a mixed culture of Indian and Tibetan traits. Darjeeling hills and Sikkim is a mixture of both Hindu and Tibetan culture, while Bhutan has historically been a region of Tibetan culture. Arunachal Pradesh reflects the religion and culture similarity with the Chinese of the Yunnan province in China, while the northern part of Arunachal Pradesh has predominantly the races of Tibetan origin. North East Indian states bordering Myanmar have cultural and social affinities with the people of Myanmar. Further, notable proportions of Christians also live in Meghalaya, Mizoram, Nagaland, Darjeeling hills, Sikkim, Arunachal Pradesh, and Nepal. Migrants of Muslim population have also been observed recently in the demography of the Himalayas except Kashmir, which is the predominant ethnic Muslim region. The approximate population of the Himalayas has been estimated to be more than 65 million (Khawas 2008), with more than 171 major ethnic communities living in the Indian Himalayas (Samal et al. 2000) and 61 ethnic groups in Nepal (C. Subba 1999).

The major ethnic groups living in the Himalayas are summarized as follows based on data compiled from the reports of Jamir and Rao (1990), Census of India (2001), and Nandy et al. (2006) as well as my personal collection: Jammu & Kashmir (Dogra; Gujjar; Gaddi; Kashmiri Pundit; Sunni, Shia, Hanji, and Dard Muslims; Balti; Ladakhi), Himachal Pradesh (Rajput, Brahmin, Ghairat, Mahajan, Sood, Chahang, Saini, Air, Darni, Lohar, Tarkhan, Nai, Dusali, Doomna, Chamar, Julaha), Uttarakhand (Kol or Kolta, Rajput, Brahmin, Jaunsari, Bhotia, Buksha, Tharu), Darjeeling hills (ethnic Gorkha/Nepali [Rai, Tamang, Gurung, Limboo, Chettri, Magar, Bahun, Pradhan/Newar, Dewan, Sunwar, Bhujel, Khagatey, Sherpa, Sanyasi/Giri, Kami, Damai, Sarki, Maji], Lepcha, Tibetan), Sikkim (ethnic Nepali [Bahun, Chettri, Sanyasi/Giri, Magar, Tamang, Pradhan/Newar, Rai, Limboo, Gurung, Bhujel, Dewan, Sunwar, Khagatey, Sherpa, Kami, Damai, Sarki, Maji], Lepcha, Bhutia), Arunachal Pradesh (Monpa, Sherdukpen, Memba, Khamba, Khampti, Singpho, Adi, Aka, Apatani, Bangni, Nishing, Mishmi, Miji, Tangsa, Nocte, Wancho), Assam (Ahom, Bodo, Karbi, ethnic Nepali,

Miri, Rabha, Bengali), Meghalaya (Khasi, Garo, Jaintia, ethnic Nepali/Gorkha), Mizoram (Mizo, Hmar, ethnic Gorkha, Lakher, Pawi), Manipur (Meiti, Kuki, ethnic Gorkha), Nagaland (Angami, Chakhesang, Ao, Sema, Rengma, Lotha, Chang, Konyak, Sangtam, Phom, Zeliang, Mao, Maram, Tangkhul, Maring, Anal, Mayao-Monsang, Lamkang, Nockte, Haimi, Htangun, Ranpan, Kolyo, Kenyu, Kacha, Yachimi, Kabui, Uchongpok, Makaoro, Jeru, Somra, ethnic Gorkha), Tripura (Chakmas, Bengali), Nepal (Newar, Magar, Tamang, Rai, Limboo, Gurung, Bahun, Chettri, Dewan, Sanyasi, Bhujel, Sunwar, Khagatey, Sherpa, Kami, Damai, Sarki, Yadav, Taru, Mahji, Kumhal, Urau, Meche, Dhimal, Satar, Rajbanshi), Bhutan (Drukpa/Ngalop, Sharchop, and ethnic Nepali/Lhotshamp), Tibetan Autonomous Region (Tibetan, Chinese).

Topographically, linguistically, and culturally, the ethnic Nepali or Gorkha of Nepal, Darjeeling hills, Sikkim, and south Bhutan have similarities, with more than 20 major castes within the community (Tamang 1982). Present-day India has a sizable number of ethnic Nepali or Gorkha (Gorkha denotes the distinct ethnic Nepali of Indian origins and differentiates from the citizens of Nepal by an official gazette notification of the Indian Ministry of Home Affairs in 1988) in many states of India who contribute to the major food culture of the regions. The Gorkha inhabitants in India reside in Darjeeling hills, Sikkim, a few parts of North East India, Uttarakhand, and Himachal Pradesh. Bhutan has two distinct ethnic communities, the Drukpa of Buddhist origins and the ethnic Nepali of both Hindu and Buddhist origins. The Nepali or Gorkha typically lives a pastoral and agrarian lifestyle and has mixed culture of Aryan and Mongoloid traits.

1.4 *Food culture*

Food symbolizes the culture of a community and provides it with a distinct identity. The social forms, customary beliefs, and material traits of racial, religious, or social groups are some of the characteristics contributing to the description of a culture, while ethnicity is the affiliation with a race, people, or cultural group (McWilliams 2007). Culture and ethnicity are essential foundations of the study of food and people. Religion is a strong factor in cultural identity, and the shared common beliefs and practices that are central to a particular religion create common threads that bind people together into a culture (McWilliams 2007). Hindu food follows the concept of purity and pollution, which determines interpersonal and intercaste relationships (Misra 1986). North Indian Brahmin kitchens produce two types of meals: *kaccha*, which means unripe and uncooked, and *pakka*, meaning ripe and cooked. *Kaccha* foods are highly vulnerable to contamination and, therefore, there are strict codes of cooking, serving, and eating this food. *Pakka* foods are fried, so they are not as vulnerable (Misra 1986).

Ethnic foods are generally categorized into fermented foods, including alcoholic beverages, and nonfermented foods. These inexpensive and culturally accepted ethnic foods provide the basic diet for the people. Ever since ethnic people have inhabited the Himalayan regions—ranging from the foothills to the alpine region—hunting, gathering, and utilization of available plants, animals, and their products for consumption started and gradually emerged as the ethnic food culture of the present day (Tamang 2001a). Ethnic food culture harnesses the cultural history of ethnic communities, including their indigenous knowledge of food production with vast nutritious qualities as well as microbial diversity associated with fermented foods, as a genetic resource. The food culture or dietary culture of the Himalayan people presents a kaleidoscopic panorama (Tamang 2005a). Each food prepared by different ethnic communities in the Himalayas is unique and unparalleled, due to the geographical location, food preferences, and availability of raw substrates or locally grown agricultural products or animal sources.

The Himalayan culture is wedged between the rich Hindu-Aryan culture in the south and the Buddhist-Mongolian culture in the north. Thus, the Himalayan food culture is a fusion of the Hindu and the Tibetan cuisines, with modifications based on ethnic preference and social ethos over a period of time. The Himalayan regions bordering Tibet (in China)—Ladakh, Lahul & Spiti, Kinnaur & Kalpa, Chamoli, Pithorgarh, hills of Nepal, Sikkim, Darjeeling hills, Bhutan, and north Arunachal Pradesh—have a close cultural affinity with the Tibetans, which has influenced the food cultures of the regions, while in the predominantly Hindu regions, mostly in the foothills and *tarai* or plain areas of the Himalayas, have been influenced by the vegetarian diets of the Hindus. Migration of people carrying the food culture and habits may also influence the settlers, thus leading to cultural amalgamation or fusion over a period of time. Moreover, the political history of Nepal has undergone several changes in its demography since 600 b.c. until the eighteenth century a.d. (Pradhan 1982). The greater Nepal extended from Himachal Pradesh to the Far East of Assam until 1816, when the British annexed the territories of Nepal into India by signing the famous Treaty of Sugauli on 4 March 1816 (Pradhan 1982). Darjeeling hills was a territory of the Sikkim kingdom until 1835, when it was handed over to the British on a lease agreement by the *chogyals* or kings of Sikkim (Bhanja 1993).

The Himalayan ethnic foods have evolved as a result of traditional wisdom and the experiences of generations over a period of time, based on agroclimatic conditions, availability of edible resources, ethnic preference, customary beliefs, religion, socioeconomy, regional politics, cultural practices, and taboos or social bans imposed by different rulers from time to time. Rice or maize is a staple food in the eastern Himalayas, whereas wheat or barley is a staple food in the western Himalayas.

Bhat-dal-sabji-tarkari-dahi/mohi-achar combination, which corresponds to steamed rice-legume soup-vegetable-curry-curd/buttermilk-pickle, is a typical recipe of every meal in the eastern Himalayas, and roti/chapati-*dal-sabji-dahi-achar*, corresponding to baked bread/roti-legume soup-vegetable curry-curd-pickle, is a typical recipe of every meal in the western Himalayas. Though the people of the eastern Himalayas are mainly rice eaters, nowadays, roti or chapati (wheat-based baked bread) is replacing this traditional habit, particularly among the urban population. *Dhenroh* (boiled maize flour) is substituted for rice and is commonly eaten with *mohi* (buttermilk) in rural areas in Nepal, Bhutan, Darjeeling hills, and Sikkim. The food culture of the Himalayas is very rich, having more than 100 types of ethnic fermented food and 50 types of ethnic alcoholic beverages, more than 300 types of nonfermented ethnic foods, and about 350 wild edible plants as staples, snacks, condiments, refreshments, desserts, pickles, alcoholic drinks, savories, etc.

The daily life of a typical Himalayan person (in this case a typical example of a Nepali of the Himalayas) starts in the morning with a full mug of tea taken with sugar or salt, with or without milk and with or without a pinch of black pepper. The first meal eaten in the morning is a simple recipe containing *bhat-dal-sabji-tarkari-dahi/mohi-achar. Tarkari* meaning side dish or curry, includes a variety of ethnic fermented and nonfermented food items. It is followed by light refreshment with mostly traditional snacks and tea in the afternoon. The second major meal is dinner, which is served early in the evening, and which consists of the same *bhat-dal-sabji-tarkari-dahi/mohi-achar.* The food culture of *matwali* Nepali (who drink alcohol as a part of their social provision) includes ethnic fermented beverages and distilled alcoholic drinks as part of the evening meal (Tamang 2009). Tibetans, Bhutia, Drukpa, and Lepcha usually eat *tukpa* (noodles in soup), *skiu* or *momo* (small dumplings of wheat flour with meats), baked potatoes, *tsampa* (ground roasted barley grains), *chhurpi* (cottage cheese), *kargyong* and *gyuma* (sausages), butter tea, and *chyang* (alcoholic beverage). The ethnic people of North East India have a social provision of drinking traditional alcohol with fermented or smoked fish and other dishes. In the high mountains (above 2500-m elevation), yak milk and its products are popular food items. Milk and milk products are more popular in the western Himalayas than the eastern Himalayas except for Darjeeling hills, Sikkim, and Bhutan. In North East India, except for Assam and Tripura, milk and milk products are not the traditional food items; hence, fermented milk products have not been reported from Meghalaya, Nagaland, Mizoram, Manipur, and several parts in Arunachal Pradesh, where pastoral systems are rare.

The common connotation in Nepali cuisine is *chawrasi vyanjanas*, i.e., Nepali cuisine has 84 different food items. The Himalayan food is less spicy and is traditionally prepared in butter from cow milk or yak

milk, although commercial edible oil is now also used. The majority of the Himalayan ethnic people are nonvegetarians except for the Brahmin communities, who are strict vegetarians. Due to health-conscious and rapid electronic advertisements on health and nutrition, the food habits in the urban areas of the Himalayas are changing to the vegetarian diet. Nonvegetarians eat chicken, eggs, mutton, lamb, chevon (goat), pork, beef, buffalo, yak, fish, etc. Beef and yak are taboo to a majority of the communities belonging to the Nepali, Garwhali, Kumauni, Assamese, and people from Himachal Pradesh. The Newar/Pradhan people prefer to eat buffalo meat. Cooking is usually done by daughters-in-law, daughters, and mothers. The custom of serving meals to the elder male members in the family is prevalent in the Himalayan food culture. Daughters-in-law and daughters eat afterwards, a tradition that is still followed in the rural areas. This trend of serving meals to elders and eating separately is changing in the urban areas, where families often eat together.

The Himalayan peoples have unique practices of storing of foods. *Maa* (in the Tibetan language) butter made from yak milk is commonly stored in the animal's stomach in the Tibetan villages in Ladakh (Attenborough et al. 1994), whereas *gheu* (in the Nepali language) butter made from cow milk is stored in a wooden or bamboo container by the Nepali in Nepal, Darjeeling hills, and Sikkim. This is due to the local availability of storage containers, since bamboo is not grown in alpine regions.

The Himalayan people use their hands, after washing properly, to feed themselves. Eating food by hand has been mentioned in the history of Nepal during the Lichchhavi dynasty, which spanned from 100 to 880 a.d. (Bajracharya and Shrestha 1973). Bamboo chopsticks are commonly used by the Tibetans. The use of chopsticks is not the tradition of the Himalayan people, except for the Tibetans. Plates made of brass or lined with brass, called *kasa ko thal*, are traditionally used by the majority of rural Nepali, Kumauni, Garwhali, etc. The rich people or rulers used to feed from golden or silver plates with decorations. Small soup bowls are used by the Tibetans, Bhutia, Lepcha, and Drukpa of Bhutan. Locally available tree leaves, commonly from the fig plant, are also used in some parts of North East India for serving foods.

1.5 *Fusion of Western and Eastern food cultures*

Rice is a staple food for millions of people in Southeast Asia, whereas wheat or barley is a staple food in Northwest Asia, Europe, America, and Australia. A typical diet of Southeast Asia comprises rice, followed by fermented and nonfermented soybean products, pickled vegetables, fish, and alcoholic beverages, whereas a typical diet of Northwest Asia comprises wheat/barley as a staple food, followed by milk and fermented milks, and meat and meat products; wine is a typical dietary culture of Northwest

Asia, Europe, America, and Australia. African food habits include both fermented and nonfermented cereal products, wild legume seeds, tubers, and cassava as staple foods, followed by meat, milk products, and alcoholic beverages. In Asia, fruits are eaten directly, whereas in Europe, America, and Australia, fruits are fermented into wine. It is interesting to note that the Himalayan food culture has both rice and wheat or barley as staple foods along with varieties of fermented and nonfermented foods prepared from soybean, vegetable, bamboo, milk, meat, fish, cereal, etc. Himalayan cuisines also include diverse types of wild edible plants and fruits. Milk and meat products, similar to the West, and fermented soybeans and alcoholic beverages, similar to the East, are common in the food culture of the eastern Himalayas. Traditionally, animal milk is not consumed by the Chinese, Koreans, Japanese, etc., despite of an abundance of milk-producing animals in their possession. On the other hand, the Indo-Europeans, Semites, and the nomadic tribesmen of North Central Asia are milk drinkers (Laufer 1914). In the Far East, the soybean, sometimes called the "cow of China," is utilized in liquid, powder, or curd forms to make soy milk, tofu (soy curd), and a number of fermented soybean products such as miso, shoyu, *natto*, tempeh, *sufu*, etc. (Hymowitz 1970).

Examination of the microbiology of traditional fermented foods of East and Southeast Asia shows that the molds (*Rhizopus, Mucor, Aspergillus*) are the predominant mycelial fungi, followed by amylolytic and alcohol-producing yeasts (*Saccharomyces, Saccharomycopsis, Pichia*), nonpathogenic species of bacilli (mostly *B. subtilis*), and few lactic acid bacteria (LAB). In contrast, in Northwest Asia, Europe, America, Australia, and Africa, fermented food products are prepared exclusively using bacteria, mostly lactic acid bacteria or a combination of lactic acid bacteria and yeasts; molds seem to be seldom and bacilli are never used in production of fermented foods except in a few ethnic African foods such as *dawadawa* and *iru* (fermented African locust bean products). However, in the eastern Himalayas, all three major groups of microorganism (mycelial fungi, alcohol- and enzyme-producing yeasts, and bacteria) are associated with ethnic fermented foods and beverages. Most of the fermented foods in Asia are prepared naturally or spontaneously, whereas in Western countries, the majority of foods are prepared by using pure starter cultures (either strains of LAB or a combination of LAB and yeasts). The use of traditionally made mixed, dry starter cultures containing filamentous molds, starch-degrading and alcohol-producing yeasts, and LAB for production of alcoholic beverages is a common practice in Southeast Asia, including the Himalayas. *Bacillus*-fermented sticky soybean foods of the eastern Himalayas are similar to sticky fermented soybean foods of other South Asian countries such as *pepok* of northern Myanmar, *thua-nao* of northern Thailand, *sieng* of Cambodia, *chungkokjang* of Korea, and *natto*

of Japan. However, consumption of *Bacillus*-fermented sticky soybean food is uncommon in the rest of the world, including entire Indian states except North East India. The food culture, mainly the ethnic fermented foods, of the eastern Himalayas is probably a transition of the food cultures of the East and West.

1.6 *What are ethnic fermented foods?*

Ethnic fermented foods are produced, based on the indigenous knowledge of the ethnic people, from locally available raw materials of plant or animal sources either naturally or by adding starter culture(s) containing functional microorganisms that modify the substrates biochemically and organoleptically into edible products that are culturally and socially acceptable to the consumers. Functional bacteria—mostly lactic acid bacteria, yeasts, and filamentous molds—bring biotransformation of the raw or cooked materials of plant or animal origin during fermentation, enhancing nutritional value; prolonging the shelf life; improving flavor, texture, and aroma; and also exerting several health-promoting benefits (Steinkraus 1996; Hansen 2002; Tamang 2007a). Fermented foods are generally palatable, safe, and nutritious (Campbell-Platt 1994; Geisen and Holzapfel 1996; Kwon 1994). Traditional methods of food fermentation serve as affordable and manageable techniques of biopreservation of perishable agricultural or animal products without refrigeration, freezing, cold storage, and canning. The essential objective of food fermentation is to carry over supplies from the times of plenty to those of deficit.

The Himalayan people developed such innovative technology without any knowledge of food microbiology or the actual scientific mechanism involved in it, but certainly they know how to use the beneficial (functional) microorganisms for production of foods of their choice and know what needs to be done to get the desired food products. The microbiology, biochemistry, nutrition, functionality, toxicology, food safety, and biotechnology of their fermented foods are unknown to the producers, who are simply practicing an age-old food fermentation technology.

The ethnic fermented foods and beverages, which include soybeans, milk, meat, fish, vegetable, cereals, and alcoholic beverages, constitute the basic dietary culture of the Himalayan people using their indigenous knowledge of food preservation and substrate utilization (Tamang et al. 1988; Tamang 2005b, 2009). More than 150 different types of familiar and less-familiar ethnic fermented foods and beverages of the Himalayas have been listed in Table 1.1. Most of these Himalayan fermented foods and beverages have been studied by our team of researchers for the last 20 years. The history of the development of most of these ethnic fermented foods is lost; however, some of these ethnic foods have been prepared

Table 1.1 Himalayan Fermented Foods and Beverages

Food	Substrate	Nature of product	Microbes	Region
1. Fermented vegetables				
Gundruk	Leafy vegetable	Dried, sour-acidic; soup, pickle	LAB	Nepal, Darjeeling hills, Sikkim, Bhutan
Inziang-sang	Mustard leaves	Dried, sour; soup, curry	LAB	Nagaland, Manipur
Inziang-dui	Mustard leaves	Liquid, sour; condiment	LAB	Nagaland, Manipur
Goyang	Green vegetable	Freshly fermented; juice as condiment, soup	LAB	Sikkim, Nepal
Sinki	Radish tap-root	Dried, sour-acidic; soup, pickle	LAB	Nepal, Darjeeling hills, Sikkim, Bhutan
Khalpi	Cucumber	Sour; pickle	LAB	Nepal, Darjeeling hills, Sikkim
Mesu	Bamboo shoot	Sour; pickle	LAB	Nepal, Darjeeling hills, Sikkim, Bhutan
Soibum	Bamboo shoot	Sour-acidic; curry	LAB	Manipur
Soidon	Bamboo shoot tips	Sour-acidic; curry	LAB	Manipur
Soijim	Bamboo shoot	Liquid, sour; condiment	LAB	Manipur
Ekung	Bamboo shoot	Sour-acidic; curry, soup	LAB	Arunachal Pradesh
Hirring	Bamboo shoot tips	Sour-acidic; curry, soup	LAB	Arunachal Pradesh
Eup	Bamboo shoot	Dry, acidic; curry, soup	LAB	Arunachal Pradesh
Lung-siej	Bamboo shoot	Sour-acidic; curry	LAB	Meghalaya
Bastanga	Bamboo shoot	Sour-acidic; curry	Unknown	Nagaland
Sinnamani	Radish	Freshly fermented, sour; pickle	Unknown	Nepal
Anishi	Taro leaves	Fermented; sour; curry	Unknown	Nagaland

2. Fermented legumes

Kinema	Soybean	Sticky, flavored; curry	*Bacillus subtilis*	East Nepal, Darjeeling hills, Sikkim, Bhutan
Hawaijar	Soybean	Sticky, flavored; side dish as fish substitute	*Bacillus* spp.	Manipur
Tungrymbai	Soybean	Sticky, flavored; curry	*Bacillus* spp.	Meghalaya
Aakhone	Soybean	Sticky or dry-cakes; side dish	*Bacillus* spp.	Nagaland
Bekang	Soybean	Sticky, flavored; side dish	*Bacillus* spp.	Mizoram
Peruyaan	Soybean	Sticky, soybeans; curry	*Bacillus* spp.	Arunachal Pradesh
Maseura	Black gram	Dry, ball-like; condiment	Bacilli, LAB and yeasts	Nepal, Darjeeling hills, Sikkim

3. Fermented milk products

Dahi	Cow milk	Curd; savory	LAB, yeasts	All
Shyow	Yak milk	Curd; savory	LAB, yeasts	Sikkim, Bhutan, Tibet, Ladakh
Gheu	Cow milk	Butter	LAB, yeasts	All
Maa	Yak milk	Butter	LAB, yeasts	Sikkim, Bhutan, Tibet, Ladakh
Mohi	Cow milk	Buttermilk; refreshing beverage	LAB, yeasts	Eastern Himalayas
Lassi	Cow milk	Buttermilk; refreshing beverage	LAB, yeasts	Western Himalayas
Chhurpi (soft)	Cow milk	Soft, cheese-like; curry, pickle	LAB, yeasts	Nepal; Darjeeling hills, Sikkim
Chhurpi (hard)	Yak milk	Hard-mass, masticator	LAB, yeasts	Nepal, Darjeeling hills, Sikkim, Bhutan, Tibet, Ladakh, Arunachal Pradesh, Himachal Pradesh

(continued on next page)

Table 1.1 (continued) Himalayan Fermented Foods and Beverages

Food	Substrate	Nature of product	Microbes	Region
Dudh chhurpi	Cow milk	Hard-mass, masticator	LAB, yeasts	Nepal, Darjeeling hills, Sikkim, Bhutan
Phrung	Yak milk	Hard-mass, masticator	Unknown	Arunachal Pradesh
Chhu or sheden	Cow/yak milk	Soft, strong flavored; curry	LAB, yeasts	Sikkim, Bhutan
Chur yuupa	Yak milk	Soft, flavored; curry, soup	Unknown	Arunachal Pradesh
Somar	Cow/yak milk	Paste, flavored; condiment	LAB	Nepal, Darjeeling hills, Sikkim
Dachi	Cow/yak milk	Soft, cheese-like, strong flavored; hot curry	Unknown	Bhutan
Philu	Cow/yak milk	Cream; fried curry with butter	LAB	Sikkim, Bhutan, Tibet
Pheuja or Suja	Tea, yak butter	Fermented butter tea	Unknown	Sikkim, Bhutan, Tibet, Ladakh
Paneer	Whey of cow milk	Soft, cheese-like product; fried snacks	LAB	Western Himalayas
4. Fermented cereals				
Selroti	Rice, wheat flour, milk	Pretzel-like, deep fried; bread	Yeasts, LAB	Nepal, Darjeeling hills, Sikkim, Bhutan
Jalebi	Wheat flour	Crispy sweet, deep fried pretzels; snacks	Yeasts, LAB	Western Himalayas
Nan	Wheat flour	Leavened bread; baked; staple	Yeasts, LAB	Western Himalayas
Siddu	Wheat flour, opium seeds, walnut	Steamed bread, oval-shaped; staple	Unknown	Himachal Pradesh, Uttarakhand

Chilra	Wheat, barley, buckwheat	Like dosa; staple	LAB, yeasts	Himachal Pradesh, Uttarakhand
Marchu	Wheat flour	Baked breads; staple	Unknown	Himachal Pradesh
Bhaturu	Wheat flour	Baked breads; staple	LAB, yeasts	Himachal Pradesh, Uttarakhand
Seera	Wheat grains	Dried, sweet dish	Unknown	Himachal Pradesh
5. Fermented/dry fish products				
Suka ko maacha	River fish	Smoked, sun-dried; curry	LAB, *Bacillus*, yeasts	Nepal, Darjeeling hills, Sikkim
Gnuchi	River fish	Smoked; curry	LAB, *Bacillus*, yeasts	Darjeeling hills, Sikkim
Sidra	Fish	Dried fish; curry	LAB, yeasts	Nepal, Darjeeling hills, Sikkim, Bhutan
Sukuti	Fish	Dried fish; curry	LAB, yeasts	Nepal, Darjeeling hills, Sikkim, Bhutan
Ngari	Fish	Fermented fish; curry	LAB, yeasts	Manipur
Hentak	Fish and petioles of aroid plants	Fermented fish paste; curry	LAB, yeasts	Manipur
Tungtap	Fish	Fermented; pickle	LAB, yeasts	Meghalaya
Karati	Fish	Dried, salted; curry	LAB, yeasts	Assam
Bordia	Fish	Dried, salted; curry	LAB, yeasts	Assam
Lashim	Fish	Dried, salted; curry	LAB, yeasts	Assam
Mio	Fish	Dried; curry	Unknown	Arunachal Pradesh
Naakangba	Fish	Sun-dried; pickle, curry	Unknown	Manipur
Ayaiba	Fish	Smoked fish; pickle, curry	Unknown	Manipur

(continued on next page)

Table 1.1 (continued) Himalayan Fermented Foods and Beverages

Food	Substrate	Nature of product	Microbes	Region
6. Fermented/dry meat products				
Lang kargyong	Beef	Sausage (soft or hard, brownish); curry	LAB	Sikkim, Darjeeling hills, Bhutan, Tibet, Arunachal Pradesh, Ladakh
Yak kargyong	Yak	Sausage (soft, brownish); curry	LAB	Sikkim, Bhutan, Tibet, Arunachal Pradesh, Ladakh
Faak kargyong	Pork	Sausage (soft or hard, brownish); curry	LAB	Sikkim, Darjeeling hills, Bhutan, Tibet
Lang satchu	Beef meat	Dried or smoked meat (hard, brownish); curry	LAB	Sikkim, Darjeeling hills, Bhutan, Tibet, Ladakh
Yak satchu	Yak meat	Dried or smoked meat (hard, brownish); curry	LAB	Sikkim, Darjeeling hills, Bhutan, Tibet, Arunachal Pradesh, Ladakh
Suka ko masu	Buffalo meat	Dried or smoked meat (hard, brownish chocolate); curry	LAB	Nepal, Darjeeling hills, Sikkim
Yak chilu	Yak fat	Hard, used as substitute of an edible oil	LAB	Sikkim, Bhutan, Tibet, Arunachal Pradesh, Ladakh
Lang chilu	Beef fat	Hard, used as an edible oil	LAB	Sikkim, Bhutan, Tibet, Ladakh
Luk chilu	Sheep fat	Hard, used as an edible oil	LAB	Sikkim, Bhutan, Tibet, Ladakh, Nepal
Yak kheuri	Yak	Chopped intestine of yak; curry	LAB	Sikkim, Bhutan, Tibet, Arunachal Pradesh, Ladakh
Lang kheuri	Beef	Chopped intestine of beef; curry	LAB	Sikkim, Bhutan, Tibet, Arunachal Pradesh, Ladakh
Chartayshya	Chevon	Dried/smoked meat; curry	LAB, bacilli, micrococci, yeasts	Kumaon hills of Uttarakhand

Jamma	Small intestine of chevon, finger millet	Sausage (soft); curry	LAB, bacilli, micrococci, yeasts	Kumaon hills, western Nepal
Arjia	Large intestine of chevon	Sausage; curry	LAB, bacilli, micrococci, yeasts	Kumaon hills, western Nepal
Bagjinam	Pork	Fermented pork; curry	Unknown	Nagaland
Sukula	Buffalo	Dried/smoked meat; curry	Unknown	Nepal
7. Mixed-starter cultures				
Marcha	Rice, wild herbs, spices	Dry, mixed starter to ferment alcoholic beverages	Molds, yeasts, LAB	Eastern Himalayas
Phab	Wheat, wild herbs	Dry, mixed starter to ferment alcoholic beverages	Molds, yeasts, LAB	Sikkim, Bhutan, Tibet, Ladakh
Ipoh/Siye	Rice, wild herbs	Starter to ferment alcoholic beverages	Unknown	Arunachal Pradesh
Hamei	Rice, wild herbs	Dry, mixed starter to ferment alcoholic beverages	Molds, yeasts, LAB	Manipur
Mana	Wheat, herbs	Starter to ferment alcoholic beverages	*Aspergillus oryzae*	Nepal
Manapu	Rice-wheat, herbs	Starter to ferment alcoholic beverages	Yeasts and molds	Nepal
Emao	Rice-herbs	Starter to ferment alcoholic beverages	Unknown	Assam
Thiat	Rice-herbs	Starter to ferment alcoholic beverages	Unknown	Meghalaya

(continued on next page)

Table 1.1 (continued) Himalayan Fermented Foods and Beverages

Food	Substrate	Nature of product	Microbes	Region
8. Alcoholic beverages and distilled liquor				
Phaṃ	Rice-herbs	Starter to ferment alcoholic beverages	Unknown	Arunachal Pradesh
Khekhrii	Germinated rice	Starter to ferment *zutho/zhuchu*	Unknown	Nagaland
Balan	Wheat	Starter to ferment alcoholic beverages	Unknown	Uttarakhand
Bakhar	Rice-herbs	Starter to ferment alcoholic beverages	Yeasts	Western Himalayas
Kodo ko jaanr	Finger millet	Mildly alcoholic, slightly sweet-acidic; alcoholic beverage	Yeasts, LAB	Eastern Himalayas
Chyang/ Chee	Finger millet/ barley	Mildly alcoholic, slightly sweet-acidic; alcoholic beverage	Yeasts, LAB	Sikkim, Bhutan, Tibet, Ladakh
Bhaati jaanr	Rice	Mildly alcoholic, sweet-sour, food beverage	Yeasts, LAB	Nepal, Darjeeling hills, Sikkim
Makai ko jaanr	Maize	Mildly alcoholic, sweet-sour, food beverage	Yeasts, LAB	Nepal, Darjeeling hills, Sikkim
Gahoon ko jaanr	Wheat	Mildly alcoholic, slightly acidic; alcoholic beverage	Yeasts, LAB	Nepal, Darjeeling hills, Sikkim
Simal tarul ko jaanr	Cassava tuber	Mildly alcoholic, sweet-sour; food beverage	Yeasts, LAB	Nepal, Darjeeling hills, Sikkim
Jao ko jaanr	Barley	Mildly alcoholic, slightly acidic; alcoholic beverage	Yeasts, LAB	Nepal, Darjeeling hills, Sikkim
Faapar ko jaanr	Buckwheat	Mildly alcoholic, slightly acidic; alcoholic beverage	Yeasts, LAB	Nepal, Darjeeling hills, Sikkim

Atingba	Rice	Mildly alcoholic, sweet-sour, food beverage	Unknown	Manipur
Apong	Rice	Mildly alcoholic, beverage	Unknown	Arunachal Pradesh
Pona	Rice	Mildly alcoholic, sweet-sour, food beverage; paste	Unknown	Arunachal Pradesh
Ennog	Rice, paddy husk	Black rice beer	Unknown	Arunachal Pradesh
Jou	Rice	Alcoholic beverage	Unknown	Nagaland
Zutho/ Zhuchu	Rice	Milky white, alcoholic beverage	LAB, yeasts	Nagaland
Oh	Rice-millet	Soft, alcoholic beverage	Unknown	Arunachal Pradesh
Themsing	Finger millet/barley	Alcoholic beverage	Unknown	Arunachal Pradesh
Mingri	Maize-rice/barley	Alcoholic beverage	Unknown	Arunachal Pradesh
Lohpani	Maize-rice/barley	Alcoholic beverage	Unknown	Arunachal Pradesh
Zu	Rice	Alcoholic beverage	Unknown	Assam
Sura	Finger millet	Food beverage; staple	Unknown	Himachal Pradesh
Lugri	Barley	Alcoholic beverage	Yeasts	Himachal Pradesh, Ladakh, Tibet
Sing sing	Barley	Beverage	Yeasts	Ladakh
Buza	Barley	Thick liquor	...	Ladakh
Raksi	Cereals	Clear distilled liquor; alcoholic drink	Yeasts, LAB	Eastern Himalayas
Aara	Cereals	Clear distilled liquor; alcoholic drink	Unknown	Arunachal Pradesh
Duizou	Red rice	Alcoholic drink	Unknown	Nagaland
Nchiangne	Red rice	Distilled liquor	Unknown	Nagaland
Ruhi	Rice	Distilled liquor	Unknown	Nagaland
Madhu	Rice	Distilled liquor	Yeast, Mold	Nagaland
Yu	Rice	Distilled liquor	Unknown	Manipur

(continued on next page)

Table 1.1 (continued) Himalayan Fermented Foods and Beverages

Food	Substrate	Nature of product	Microbes	Region
Kiad-lieh	Rice	Distilled liquor	Unknown	Meghalaya
Poko	Rice	Food beverage	Yeasts, LAB	Nepal
Bhang-chyang	Maize-rice/barley	Extract of *mingri*; alcoholic beverages	Unknown	Arunachal Pradesh
Daru	Cereal	Alcoholic beverages; filtrate; jiggery	Unknown	Himachal Pradesh
Chulli	Apricot	Alcoholic beverages; filtrate; alcoholic drink	Unknown	Himachal Pradesh
9. Miscellaneous fermented products				
Achar or chutney	Fruits, vegetables, mixed with oil, salt	Acidic, hot and sour; pickles	LAB	The Himalayas
Black Tea	Tea	Nonalcoholic drink	Unknown	The Himalayas
Kombucha or tea fungus	Tea liquor	Nonalcoholic drink	LAB, Yeasts	Tibet, Ladakh
Chuk	Fruits	Dark-brown paste, sour bitter taste; therapeutic uses	Unknown	Nepal, Darjeeling hills, Sikkim
Hakua	Rice	Strong off-flavor; fermented paddy	Unknown	Nepal, Darjeeling hills, Sikkim
Crabs	Crabs	Side dish	Unknown	Nagaland

and consumed for centuries, probably for more than 2500 years. A few products are lesser known and confined to particular communities and specific regions in the Himalayas. The mountain women play an important role with their indigenous knowledge of food fermentation. Their participation spans from cultivation to harvesting, fermentation to culinary skills, and production to marketing. Rural women also sell the ethnic food products in local markets and earn their livelihood, thereby directly or indirectly enhancing the regional economy.

1.6.1 Microbiology of fermented foods

Fermented foods harness diverse functional microorganisms from the environment (Tamang 2002). Microorganisms are present in or on the ingredients, utensils, and the general environment, and they are selected through adaptation to the substrate for fermentation (Hesseltine 1983; Steinkraus 1997; Tamang 1998a). In the Indian subcontinent, mostly due to wide variation in agroclimatic conditions and the diverse forms of food culture of different ethnic peoples, a diversity of microorganisms is associated with traditional fermented foods and beverages (Soni and Sandhu 1990b; Tamang 1998a; Tamang and Holzapfel 1999). Microorganisms change the chemical composition of raw materials during food fermentation, enhancing the nutritive value; enriching the bland diet with improved flavor and texture; preserving the perishable foods; fortifying the products with essential amino acids, vitamins, and minerals; degrading the undesirable components and antinutritive factors; improving the digestibility; and stimulating the probiotic functions (Steinkraus 1994; Stiles and Holzapfel 1997; Adams and Nout 2001).

Any food researcher studying fermented food should accomplish the following objectives, such as determination of microbial profiles, isolation, enrichment, purification, phenotypic and genotypic characterization, proper identification of functional microorganisms, and preservation and deposition of identified strains in microbial culture collection centers. Authentic identification of functional microorganisms associated with the production of final edible products is an important aspect of microbial properties that determine the quality of the product (Tamang and Holzapfel 1999). Studies on the nutritional profile, technological or functional properties, food safety, process optimization, medicinal value, etc., are also important aspects of fermented foods. Genotypic identification using molecular methods such as DNA base composition, DNA hybridization, and ribosomal RNA and chemotaxonomical tools such as cell wall studies, cellular fatty acids, and isoprenoid quinones are helpful when the conventional approach of identification is not reliable. These ethnic fermented foods have been extensively studied, and the functional microorganisms have been isolated, properly characterized, and identified,

based on modern phenotypic (API and Biolog systems) and genotypic characteristics (RAPD-PCR, rep-PCR, species-specific PCR techniques, 16S rRNA sequencing, DNA-DNA hybridization), and preserved in 15% glycerol at –20°C.

Three major groups of microorganisms are present or associated with ethnic fermented foods: bacteria (mostly lactic acid bacteria), yeasts, and mycelial fungi. Lactic acid bacteria are Gram-positive, nonsporing, catalase-negative, devoid of cytochromes, of nonaerobic habitat but aerotolerant, fastidious, acid-tolerant, and strictly fermentative, with lactic acid as the major end product during sugar fermentation (Axelsson 1998). LAB produce lactic acid during traditional fermentation, the characteristic fermentative product, which reduces the pH of the substrate to a level where growth of putrefactive, pathogenic, and toxinogenic bacteria are inhibited (Holzapfel et al. 1995). The LAB that are usually designated as GRAS (generally recognized as safe) status in foods (Donohue and Salminen 1996) can also exert a biopreservative effect (Holzapfel et al. 2003). The genera of LAB most often present in foods are *Carnobacterium, Enterococcus, Lactobacillus, Lactococcus, Leuconostoc, Oenococcus, Pediococcus, Streptococcus, Tetragenococcus, Vagococcus,* and *Weissella* (Stiles and Holzapfel 1997; Carr et al. 2002). The advantages of lactic acid food fermentations include resistance to spoilage and food toxins, which make the foods less likely to transfer pathogenic microorganisms. They also preserve the foods between the time of harvest and consumption, modify the flavor of the original ingredients, and improve the nutritional value (Nout and Ngoddy 1997; Salminen and Wright 1998). LAB are the dominant microorganisms in many traditional fermented foods. Among nonlactic bacteria, *Bacillus* is mostly encountered in many Asian fermented soybean foods and also in some African fermented foods. The most common species reported in fermented foods are *B. subtilis* and *B. natto,* along with *B. licheniformis, B. thuringiensis, B. megaterium,* etc. (Kiers et al. 2000). *Bacillus* is an endospore forming, rod-shaped, Gram-positive, catalase positive, motile, and aerobic to semi-anaerobic growing bacterium (Gordon 1973). Some *Bacillus* strains produce λ-polyglutamic acid (PGA), which is an amino acid polymer commonly present in fermented soybean foods, giving a sticky texture (Urushibata et al. 2002).

Yeasts play vital roles in the production of many traditional fermented foods and beverages across the world (Aidoo et al. 2006), signifying the food culture of the regions and the community (Tamang and Fleet 2009). About 21 major genera with several species of functional yeasts have been isolated from fermented foods and beverages across the world, and these include *Brettanomyces* (its perfect stage, *Dekkera*), *Candida, Cryptococcus, Debaryomyces, Galactomyces, Geotrichum, Hansenula, Hanseniaspora* (its asexual counterpart *Kloeckera*), *Hyphopichia, Kluyveromyces, Metschnikowia,*

Pichia, Rhodotorula, Saccharomyces, Saccharomycodes, Saccharomycopsis, Schizosaccharomyces, Torulopsis, Trichosporon, Yarrowia, and *Zygosaccharomyces* (Kurtzman and Fell 1998; Pretorius 2000; Tsuyoshi et al. 2005; Romano et al. 2006; Tamang and Fleet 2009).

Fungi in fermented foods are relatively limited. Some of the common genera of mycelial fungi associated with fermented foods and beverages of the world are *Actinomucor, Mucor, Rhizopus, Amylomyces, Monascus, Neurospora, Aspergillus* and *Penicillium* (Hesseltine 1983, 1991; Samson 1993; Nout and Aidoo 2002). All species of *Aspergillus* and *Penicillium* are non-toxin-producing species in fermented foods (Hesseltine 1983).

Functional microorganisms present in fermented foods have many biological functions that enhance their health-promoting benefits. These biological functions include biopreservation of perishable foods, bioenrichment of nutritional value, enrichment of diet, protective properties, improvement in lactose metabolism, production of enzymes, antimicrobial properties, destruction of undesirable components, degradation of antinutritive factors, improved digestibility, production of antioxidants, anticarcinogenic property, therapeutic values, bioavailability of minerals, lowering of serum lipids (and cholesterol), immunological effects, prevention of infectious diseases, etc. (Tamang 2007a; Shah 2007; Liong 2008).

1.6.2 *Consumption patterns of fermented foods and beverages*

A food consumption survey is an indispensable tool for assessing the nutritional intake and pattern of food consumption by the community (Tee et al. 2004). Yonzan and Tamang (1998) for the first time conducted a brief survey on the consumption patterns of traditional fermented foods of Darjeeling hills and Sikkim in India. About 13% of fermented foods constitute the daily meal of the ethnic people of Sikkim and Darjeeling hills (Tamang et al. 2007b). The survey on food consumption patterns in Sikkim shows that 11.7% of rural people are vegetarians and 88.3% are nonvegetarians (Tamang et al. 2007b). Daily per capita consumption of ethnic fermented foods in Sikkim is shown in Table 1.2. The survey report shows that 67.7% of people prepare most of the ethnic fermented foods at home for consumption (Tamang et al. 2007b). Consumption of fermented foods to total foods is highest in the north district of Sikkim (18.6%), followed by the south (13.9%), west (13.7%), and east (7.5%) (Tamang et al. 2007b). Consumption of alcoholic beverages and meat products is higher among the Bhutia and Lepcha than the ethnic Nepali, who have heterogeneous food habits ranging from vegetarian Brahmin to nonvegetarian non-Brahmin castes.

Food consumption data are needed to develop appropriate food-based dietary guidelines for the region and to monitor changes in dietary

Table 1.2 Daily Per Capita Consumption of Fermented Foods in Sikkim

Ethnic fermented foods	Per capita consumption by different ethnic people in Sikkim (g/day)			
	Nepali	Bhutia	Lepcha	Total in Sikkim
Kinema	3.4	1.1	1.4	2.3
Maseura	0.5	0	0	0.5
Gundruk	1.7	0.9	0.6	1.4
Sinki	1.3	0.5	0.2	1.1
Mesu	0.9	0.3	0.5	0.6
Khalpi	7.3	0	0.2	6.9
Dahi (ml)	37.1	32.8	26.5	34.1
Mohi (ml)	89.7	33.8	58.9	74.2
Gheu	7.1	14.9	2.8	7.9
Chhurpi (soft)	3.4	8.1	4.0	4.5
Chhurpi (hard)	0.02	0.8	0.01	0.3
Dudh chhurpi	0.03	0.01	0	0.01
Chhu	0	5.0	7.0	5.6
Somar	0	0.1	8.3	2.8
Philu	0	0.9	0.1	0.9
Suka ko masu	6.7	30.3	9.8	16.3
Selroti	8.4	3.6	5.9	8.0
Kodo ko jaanr	71.7	124.7	115.6	101.7
Makai ko jaanr	18.9	86.4	41.7	37.8
Bhaati jaanr	14.9	8.9	8.9	10.4
Gahoon ko jaanr	30.8	56.8	14.6	26.4
Raksi (ml)	33.7	203.8	7.9	57.7

behavior and patterns. Himalayan ethnic fermented foods and beverages play an important role as sources of protein, calories, minerals, and vitamins in the local diet. Because such ethnic fermented foods are rooted in a long tradition of dietary culture, their consumption is unlikely to be changed over a short period of time.