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# Dietary culture and antiquity of the Himalayan fermented foods and alcoholic fermented beverages

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## Abstract

One of the important dietary cultures of the Himalayan people is consumption of fermented foods and drinking of alcoholic fermented beverages, which are traditionally produced by the multiracial and multiethnic communities of the Himalayan people using their 'ethno-microbiological' knowledge of food fermentation. Besides delicacy, ethnical and cultural values, the Himalayan fermented foods are also the hubs of biological resources of beneficial and functional microorganisms which have been contributing health-promoting benefits to thousands of Himalayan people with a dearth of modern food products. There is no or rare publications on sporadic history, antiquity and origin of the Himalayan fermented foods. We designed questionnaire and sought information from different communities in different places of the Himalayas on oral history, legends on origin and antiquity of fermented foods and alcoholic fermented beverages. Hence, the present article discusses the food culture, oral history, legends and antiquity of some Himalayan fermented foods and alcoholic fermented beverages in the Himalayan regions, and also to validate the scientific evidence-based ethno-microbiological practices performed by the Himalayan people for food fermentation.

**Keywords:** Himalayas, Fermented foods, Alcoholic fermented beverages, Ethno-microbiology, Dietary culture

## Introduction

Dietary culture and traditional gastronomy of the Himalayan people have evolved as a result of the sagacity, innovativeness, food preferences, availability of ago-biological resources and experiences based on trial and error over a period of time. Ethnic fermented foods are defined as foods produced by the ethnic people using their native knowledge of food fermentation from locally available raw materials of plant or animal sources either naturally/spontaneously or back-slopping or by adding starter culture(s) containing functional microorganisms which modify the substrates biochemically and organoleptically into edible products that are culturally and socially

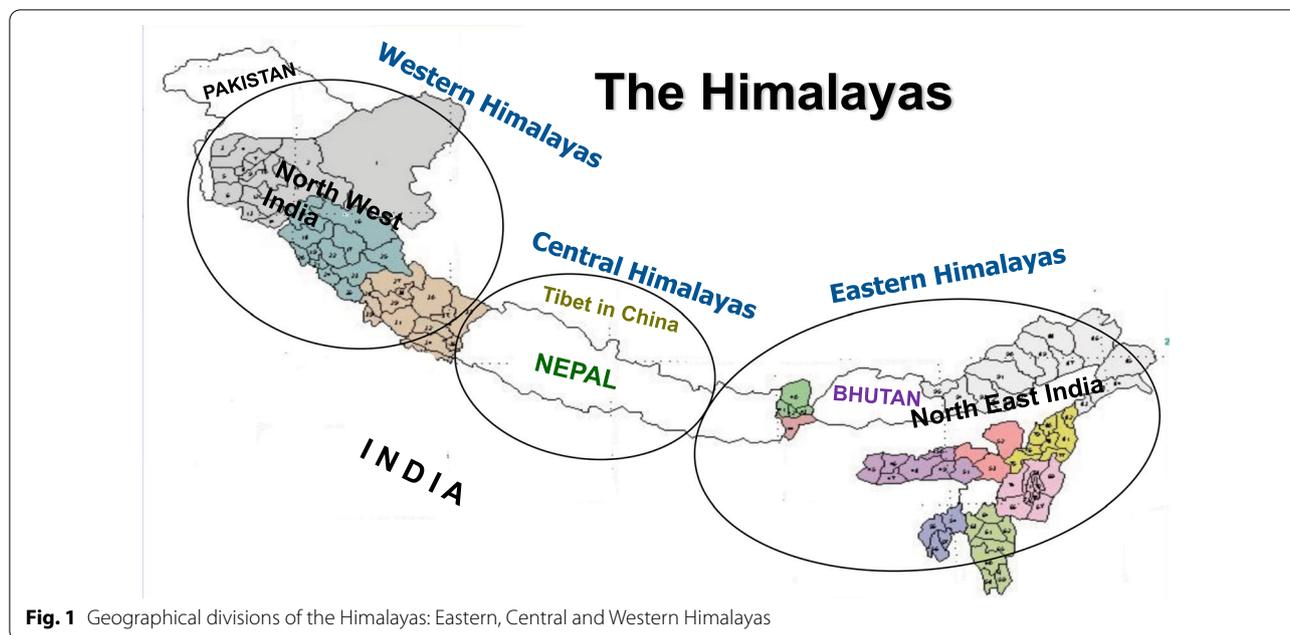
acceptable to the consumers [1]. The snow-clad Himalayas (हिमालय) are geographically divided into three regions: the Eastern Himalayas [eastern Nepal; Darjeeling hills, Sikkim, Arunachal Pradesh and states of north-east in India; Bhutan; and Tibet Autonomous Region (TAR) in China]; the Central Himalayas (central and western Nepal and TAR); and the Western Himalayas (Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand in India; and TAR) (Fig. 1). The rich biological resources including the ago-resources and livestock of the Himalayas are supportive systems for the survival and livelihood of thousands of ethnic multiracial mountain communities mostly belonging to the Aryan, the Mongoloid and the Negroid, considered as original races [2] living in the sub-Himalayan regions (ranging from 400 to 6000 m). There are rare historical records of agricultural and pastoral systems in the Himalayas; however, the oldest

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historical record of domestication of animals in Nepal was traced back to the Gopal dynasty (1500–1000 BCE) in Nepal and the agricultural systems during the Lichchavi dynasty (450–750 CE) [3]. Rice or maize is a staple food in the Eastern Himalayan regions, whereas wheat or barley is a stable diet in the Western Himalayan regions. Soya food eating culture is predominant in the Eastern Himalayan regions of India, Nepal and Bhutan. Historically animal dairy products are the traditional dietary culture of the ethnic people of the Western and Central Himalayas, whereas in the Eastern Himalayas, traditional dairy products are restricted to east Nepal, Darjeeling hills, Sikkim and Arunachal Pradesh in India and Bhutan [4]. More than 400 different types of common, unique, artisan, exotic and rare ethnic fermented foods and alcoholic fermented beverages are consumed as staple foods, side dish, curry, soup, savoury, pickles, condiments and alcoholic drinks by the multiethnic Himalayan people due to diverse geographical coordinates and ago-climatic variations (Table 1). Interestingly, the Himalayan fermented foods cover all types of available substrates ranging from milk to alcohol, soybeans to cereals, vegetables to bamboo, meat to fish, etc., and are grouped as fermented soybeans, fermented non-soybean legumes, fermented vegetables and bamboo shoots, fermented milk, fermented cereals, fermented/preserved meats and fish, consortia of microorganisms in the form of uneatable dry artisan starter culture for production of various alcoholic beverages and distilled liquor. The overall number of Himalayan fermented foods looks large; however, most of the fermented foods, based on major raw substrates,

are similar in nature with slight variations in traditional preparation methods during natural fermentation, culinary practices and mode of consumption. Moreover, listing of high number of the Himalayan fermented foods is due to colossal linguistic diversity and diverse ethnicity [5]. Every fermented product has a local name, coined by the particular ethnic Himalayan communities in their language/dialect, mostly derived from the Indo-European and Tibeto-Burman languages [6]. Ancient Himalayan people had to choose their food preferences for survival, wherever they settled in the sub-Himalayan regions, based on the accessibility and availability of plant or animal resources. That is how the localization of certain fermented foods is variable within the Himalayan regions (Table 1).

Mega diversity of the Himalayan fermented foods and alcoholic fermented beverages is historically contributed by the majority ethnic Nepali/Gorkha community, one of the earliest inhabitants of the Himalayas, comprising of more than 126 castes. Presently, the ethnic Nepali/Gorkha makes the large stallholders of the Himalayan fermented foods and alcoholic fermented beverages of India (Darjeeling hills, Sikkim, Assam, Uttarakhand), Nepal and Bhutan. Antiquity of food culture is linked with the cultural and political history as well as ethnicity of the region. Hence, the present paper discusses the food culture, legends and antiquity of some Himalayan fermented foods and alcoholic fermented beverages originated in ancient or medieval Nepal and other Himalayan regions, and to correlate the possible validation of some evidence-based traditional practices performed by the

**Table 1** Geographical distribution of ethnic fermented foods and beverages in the Himalayas

Substrates	Product characters	Himalayas		
		Western	Central	Eastern
<b>Local names of fermented products (countries/states/regions)</b>				
(A) Plant-based Himalayan fermented foods				
Soybean	Alkaline, sticky, solid	Not produced	Not produced	Aagya (AP), Axone/Aakhonii (N), Bari (B), Bekang (Mz), Bemerthu (A), Bekanthu (A), Bezeithu (T), Chukchoro, Grep chhurpi/Lipi chhurpi (AP), Hakhu mata Mn), Hawajjar (Mn), Khuichang (Mn), Kinema (Dj, S, EN, B), Penam (AP), Peruñyaan (AP), Peron Plak (AP), Paeha/peha (AP), Pintoppnanau (AP), Satyangser (S), Thonao (AP), Tungnymbai (Mg) Maseura (Dj, S)
Non-soybean legumes	Slightly acidic, solid	Borthe (HP), Dangalbari (HP), Maseura (WN), Mashbari (HP), Papad (HP), Sepubari (HP), Wari/bari (HP, U)	Maseura (WN)	
Cereal	Fermented dough, baked, fried	Aska (HP), Babru (HP), Bagpinni (HP), Bhatooru (HP), Bhatabaru (HP), Chilra (HP), Chzot/Girda (JK), Czochwor (JK), Gulgule (HP), Jalebi (HP, U, WN), Khambir (L), Lawaas (JK), Marchu (HP), Nari (HP), Pakk (HP), Selrotri (WN), Siddu (HP), Seera (HP), Tchog (HP)	Jalebi (CN), Selrotri (CN)	Jalebi (EN, Dj, S), Selrotri (EN, Dj, S, B)
Vegetable	Acidic, sour taste, sun-dried	Gundruk (WN), Sinki (WN)	Gundruk (CN), Sinki (CN)	Ankamthu (Mz), Anishi (N), Antramthu (A), Bastanga (N), Cutoce (N), Ganang tamdui, (Mn, N), Gundruk (EN, Dj, S, A, B), Goyang (S), Hungrii (N), Inziangsang and Inziang-dui (Mn, N), Kahudi and Kharoli (A), Khalpi (EN, Dj, S, B), Panitenga (A), Sinki (EN, Dj, S, B), Ziangsang (Mn, N) Bastanga (N), Ekung, Eup and Hiring (AP), Khorisa (A), Lung-siej (Mg), Mesu (EN, Dj, S, B), Miya mikhri (A), Moiya pangsung or moiya koshak (T), Soibum, Sojjim or sojjin and Soidon (Mn), Thunkhang/Thunkheng(A, Mn), Tuai-um (Mz), Thunbin (Mn), Tuathur (A)
Bamboo	Acidic, sour taste, fresh or sun-dried	Not produced	Mesu (CN)	

**Table 1** (continued)

Substrates	Product characters	Himalayas		
		Western	Central	Eastern
<i>(B) Animal-based Himalayan fermented foods</i>				
Milk	Acidic, savoury	Dahi (WH), Chhura (L), Chura loenpa (TAR), Kalarai (JK), Kurut (TAR), Lassi (WH), Mar (L), Mohi, Phuh (JK), Qula (TAR), Tara (L), Zamuthdod (JK)	Dahi (CN), Lassi (CN), Mohi (CN)	Dahi (EN, Dj, S, B, A, AP), Chhu (Dj, S), Chhurpi (EN, Dj, S, B, AP), Charka (AP), Chhur chipen (AP), Chhur singba/chhur mingba (AP), Churkam (B), Chhurpupu/Churtang (AP), Dahi, Shedan (S, B), Datshi (B), Maa/Mor/Mohi (EN, Dj, S, B), Marchang (AP), Philu (S), Phrung (AP), Shyow (S, B), Somar (Dj, S),
Fish	Fermented or traditionally preserved, sun-dried, smoked, or salted	Sidra, Suka ko maacha, and Sukuti (WN)	Sidra, Suka ko maacha, and Sukuti (CN)	Ayaiba (Mn), Boidia (A), Chucha (A), Gnuchi (Dj, S), Godak (T), Hiddal (A), Hukoti (A), Hentak (Mn), Ithitongba (Mn), Karati (A), Lashim (A), Lona Illis (T), Mio (AP), Naduba sjan, Nah-grain and Namsing (A), Naakangba (Mn, N), Ngiyya-an (AP), Ngari (M), Sepaa and Sheedal (T), Sidra, Suka ko maacha, and Sukuti (EN, Dj, S, B), Tungtap (Mg)
Meat	Fermented or traditionally preserved, sun-dried, smoked, or sausage-like products	Ajia (U, HP), Charrayshya (U, HP), Jamma (U, HP), Kheuri, Lang kargyong (L), Lang-chilu L, Shekwa (WN), Suka ko masu (WN), Yak kargyong and yak kheuri (L)	Sukako ko masu (CN), Shekwa (CN)	Ashikumma/Thevochie (N), Baginam (N), Bongkarot and Bongthu (Mn), Dingkyo (AP), Faak kargyong (Dj, S), Gwag ruum and Guaighi kang (Mn), Honoheingrain (A), Jang kap (N), Kargyong, Kheuri, Khyopeh (S), Lang kargyong (Dj, S, B), Lang satchu (Dj, S, B), Lang-chilu and Luk-chilu (S, B), Lang kheuri (S, B), Lukter (AP), Pikey Pila (AP), Saayung, Sahro and Sathu (Mn), Sa-um (Mz), Shekwa (EN), Suka ko masu (EN, Dj, S, B), Yak-chilu, Yak-kargyong, Yak kheuri and Yak satchu (S, B)
<i>(C) Himalayan amyolytic starters and alcoholic fermented beverages</i>				
Non-eatable, cereal-based starter culture	Artisan, amyolytic, solid, dry, ball or oval or flattened, starter cultures (consortia of mycelial moulds, yeasts and bacteria)	Bakhar (U, HP), Balan (U, HP), Dhehli (HP), Keem Khai (U, HP), Malera/trah (HP), Marcha, manapu and mana (WN), Phab (L)	Marcha, manapu and mana (CN)	Angkur (A), Apop pitha (A), Bhekur-pitha (A), Chamri (Mn), Chang-poo or phab (B) Chowan (T), Dabai, Dawdim (Mz), Dhehli, Ernao (A), Hamei (Mn), Humao (A), Ipoh/Siye (AP), Khai (Mn, N), Khekhrii (T), Marcha (EN, Dj, S, B), Modor pitha (A), Opop (AP), Phab (B, AP), Phut, Paa and Pee (AP), Thap (A), Thiat (Mg), Xaaz/ Xaj pitha (A)

**Table 1** (continued)

Substrates	Product characters	Himalayas		
		Western	Central	Eastern
Alcoholic fermented beverages	Cereals (rice, finger millets, maize, barley, wheat)-based mild, sweet, alcoholic beverages	<b>Local names of fermented products (countries/states/regions)</b>		
		<p>Ayela (WN), Angoori or kinnauri (HP), Arkara (HP), Chyang (L), Buza (L), Chulli (HP), Chhind, Daru (HP), Ghanti (HP), Jann (U, HP), Khor, Kodo ko jaanr (WN), Lugri (HP), Pachwai (U, HP), Rak (HP), Raksi (WN), Sez (U), Soora/Sura (HP)</p>	<p>Ayela (CN), Bhaati jaanr (CN), Kodo ko jaanr (CN), Makai ko jaanr (CN), Simal tarul ko jaanr (CN), Raksi (CN)</p>	<p>Acham (Mn), Ahom (A), Aarak or Hor-Alank (A), Aitanga (Mn), Apong (A, AP), Aara (AP), Bhaati jaanr (EN, Dj, S, B), Buza, Chakti, Chulli, Chyang (EN, Dj, S, B, AP), Chee (S), Chhind, Dekujiao and Duizou (N), Ennog (AP), Faapar ko jaanr (EN, Dj, S), Gahoon ko jaanr (EN, Dj, S), Hara (A), Jou (N), Judima (A), Juharo and Juhning (A), Kiad (Mg), Khor (Mn), Kodo ko jaanr (CN, Dj, S, B), Langi (T), Laopani (A), Madhu(N), Makai ko jaanr (EN, Dj, S, B), Mingari (AP), Nchiangne and Ndujiao (N), Nyongin (AP), Oa (AP), Opo (AP), Patso (Mn), Pheijou (Mn), Pona (AP), Raksi (EN, Dj, S, B), Rakzu (Mz), Ruzhi (N), Simal tarul ko jaanr (EN, Dj, S), Sira-Oa (AP), Themsing (AP), Timpui (Mn), Tin-zu (Mz), Toddy (A), Xai pani/ koloh pani (A), Waiyu (Mn), Yu (Mn), Yu angouba (Mn), Zoungao (Mn, N), Zouju/ zozu (Mn, N), Zu (A), Zutho (N), Zupui (Mz), Zufang (Mz)</p>
Fermented tea		Pu-erh tea (Tibet in China)		

A, Assam; AP, Arunachal Pradesh; B, Bhutan, CN, Central Nepal; Dj, Darjeeling; EN, Eastern Nepal; HP, Himachal Pradesh; JK, Jammu and Kashmir; L, Ladakh; Mg, Meghalaya; Mn, Manipur; Mz, Mizoram; N, Nagaland; S, Sikkim; T, Tripura; TAR, Tibetan Autonomous Regions in China; U, Uttarakhand; WH, Western Himalayas; WN, Western Nepal

Himalayan people during preparation of fermented foods and alcoholic fermented beverages.

## Methods

Documentation on oral history and legends of some Himalayan fermented foods and alcoholic fermented beverages has been collected and obtained through questionnaire (Table 2) and interview with local communities of different villages and regions of the Himalayan countries of India, Nepal and Bhutan during 35 years of my research. During the time of survey, many criteria were questioned and sought, which included oral history on origin and antiquity of fermented foods, methods of preparation, taboo and festivals associated with the preparation, culinary practices, socio-economy, etc. I could not visit Tibetan Autonomous Regions in China; however, I could interact and tasted the Tibetan cuisine including fermented foods of the ethnic Tibetans settled in India.

### Soya food culture and origin of soybeans

Antiquity and origin of soybean cultivation in South East Asia are still debatable, mostly based on legends and myths. Soybean, which is spelled as 'भटमास' (*bhatamāsa*) in the Nepali language, was probably introduced to the Eastern Himalayan regions of North-east India, South Bhutan and East Nepal from China from Yunnan Province of China [7], or by traders who brought soybeans via Myanmar to India [8]. Despite India being the fifth largest soybean producer country in the world, soybean was not historically and organoleptically accepted traditional food item in the Indian gastronomy except by the ethnic people of North-east India mostly belonging to the Mongolian races [9]. Local varieties of soybean seeds, viz. 'yellow cultivar' and 'dark brown/black cultivar', with

a diameter of 5–7 mm are traditionally cultivated in the upland terraces as sole crop or a mixed crop with rice and maize up in edges of the hilly terraces in the sub-Himalayan regions of east Nepal, North-east India and south Bhutan. Local varieties of Chinese soybean seeds are slightly larger than that of the Eastern Himalayas. Soybeans, mostly black varieties, are also cultivated in the Central and Western Himalayan regions of Nepal and India in the lower altitudes as major or mixed crops. Recently, several high-yielding hybrid varieties of soybeans are grown in the sub-Himalayan regions.

Historically and anthropologically, the hypothetical claim of introduction of Chinese soybeans to the Himalayan regions through north-east states of India is quite remote to establish the claim. Based on the information collected from questionnaire during the survey, mythological and legendary of origin of soybeans in the Himalayas have been mentioned in the *mundhum*, the collections of ancient religious scripture and mythology of the Limboo communities [10], who are aboriginal Kirat race of Nepal [11], believed that the soybean was gifted by their God 'Yuma' to overcome famine [4]. As per the myth, cultivation of soybeans, termed as *chembi* in Limboo language, was included in the traditional agriculture system of the Limbu. The first harvested soybean seeds were offered to the God showing their gratitude and respect for saving their life from famine as mentioned in *mundhums* might have written in between 2500 and 100 BCE [12]. The actual history of Limbuwan which was the ancient Kingdom of Limboo in eastern Nepal, currently the districts of eastern Nepal, recorded in 580 BCE till 1774 CE, after the Gorkha King Prithivi Narayan Shah merged Limbuwan to new unified Nepal [13, 14].

During the survey, we could document few legends and myths on origin of soybeans in North-east India. Ethnic

**Table 2** Questionnaire on oral history and legends of the Himalayan fermented foods and fermented alcoholic beverages

#### I. General information

1. Identification number:
3. Ethnic group:

2. Name of interviewee:

4. Name of village, district, state and country:

#### II. Information on oral history of fermented foods

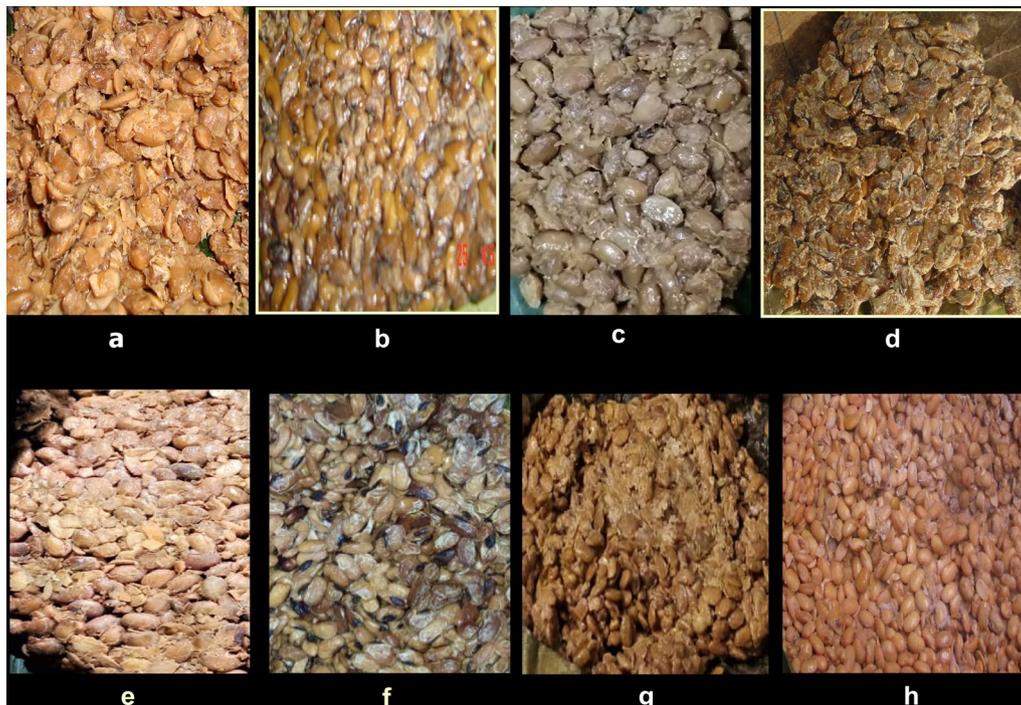
1. How did you learn the traditional methods of preparation of fermented foods? From your mothers/grandmothers/fathers/grandfathers/village elders?
2. In your knowledge how long this traditional method of fermented foods at your home being practised in your family history? Tentative year?
3. Have you heard of any oral history about the present fermented foods? If so, what and from whom?
4. Do you have any written historical documents/monographs/monuments/relics, etc., if so in which language?
5. Do you have any taboo to prepare/consume the fermented products you mentioned? Yes/No
6. If yes, provide details:
7. Do you perform any ritual or worship any particular god(s) or goddess(es) with fermented products, you consume? Yes/No
8. If yes, provide details:
9. Do you think that fermented products, which you have mentioned, have medicinal value(s) or play a role in promoting health?

inhabitants in foot hills of the sub-Himalayans regions in North-east India, viz. Meitei, Naga Mizo, Khasi, Apantani, etc., also believe having their own indigenous varieties of soybeans locally cultivated in the regions; however, the authenticity of their claim is yet to be established. Who and how domesticated soybeans were brought to the Eastern Himalayan regions remains a hypothesis. It might have brought by migrated people from regions to regions during medieval days, or by traders, or by medieval soldiers fighting in the Himalayan borders of South China, Myanmar, and Manipur, Nagaland and Arunachal Pradesh in India and then shared their indigenous practice of soybeans cultivation. However, it also depends on the cultivation of soybeans as the tradition, which is not common among the highland Tibetans in TAR, due to extreme cold climate. Hence, consumption of soybeans both fermented and non-fermented is uncommon among the Tibetans.

**Antiquity of fermented soybean foods**

Though cultivation of soybeans has been a traditional practice in the Western and Central Himalayas, natural fermentation of locally grown soybeans into delicious foods has been observed only among Mongolian races of the Eastern Himalayan regions of east Nepal North-east

India, and south Bhutan [9]. The naturally fermented soybeans with sticky texture, slight ammoniacal flavour, or *umami* flavour [15], (*umami* flavour is the flavour generated during breaking down of protein to amino acids in soybean fermentation), are commonly known as *kinema* in eastern regions of Nepal, Nepali/Gorkha-dominated Darjeeling hills and Sikkim in India, and south Bhutan, along with several other similar types of naturally fermented soybean foods with different vernacular names in North-east Indian states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland and Tripura (Fig. 2; Table 1). The word *kinema* (Fig. 2a) is believed to have derived from the word *kinamba* of the Limboo language (*ki* means fermented and *namba* means flavour) [16], probably they were the first Himalayan ethnic people who innovated the indigenous knowledge of utilization of soybeans into naturally fermented delicious foods. However, such claim has not been substantiated by the historical documents or archaeological findings. Antiquity of *kinema*, however, is yet to be fully studied. Whether *kinema* originated first and diversified to other similar products or vice versa is a big challenge to food anthropologists and historians. *Kinema* might have originated in east Nepal around 600 BCE to 100 CE during the Kirat dynasty [4].



**Fig. 2** Himalayan fermented soybean foods: **a** *Kinema* of Darjeeling hills and Sikkim in India; eastern Nepal and southern Bhutan; **b** *Hawaijar* of Manipur; **c** *Tungrymbai* of Meghalaya; **d** *Bekang* of Mizoram; **e** *Aakhonii* or *axone* of Nagaland; **f** *Peruyaon* of Arunachal Pradesh; **g** *Peron namsing* of Arunachal Pradesh; **h** *Bemertu* of Assam

Preparation of sticky fermented soybean food in the Himalayas is more or less identical with slight deviation in the production steps depending on locally available leaves/paddy straw as wrapping materials for fermenting soybean seeds, fermentation duration, culinary practice and mode of consumption. In general, first local varieties of harvested soybean seeds are selected, cleaned and soaked in water for overnight, and then soaked soybeans are transferred in a big metallic container or pot and boil till seeds become soft in an open fire in an earthen oven. Boiled seeds are cooled in bamboo-made mats for few minutes, and cooked beans are wrapped loosely in fresh fern fronds or banana leaf or other locally available fresh leaves with large surface area or paddy straw which are kept inside the bamboo-made baskets and are placed above earthen kitchen for natural fermentation for 1–3 days. After the fermentation, whitish viscous sticky materials appeared on the surface of soybean grits with slight ammoniacal flavour or umami taste and is commonly eaten as side dish curry or soup or condiments accordingly to the preference of the consumers, with steamed rice in main meal.

Himalayan sticky fermented soybean foods are similar to other Asian fermented soybean foods such as *pe poke* of Myanmar, *thua nao* of northern Thailand, *sieng* of Laos, *douchi* of Yunnan province of China, *cheonggukjang* of Korea and *natto* of Japan [16]. Hypothetically, an imaginary triangle, if drawn, starts from Japan (*natto*), touching Korea (*cheonggukjang*), Yunnan Province of China (*douchi*), Laos (*sieng*), northern Thailand (*thua-nao*), North-east India (*axone/aakhonii*, *bekang*, *bemerthu*, *bekanthu*, *bezeithu*, *grop chhurpi*, *hawaijar*, *kinema*, *peruñyaan*, *peron*, *paeha/peha*, *tungrymbai*), south Bhutan (*kinema/bari*), and ending at eastern regions of Nepal (*kinema*). This imaginary triangle was named as ‘*natto triangle*’ [17] and renamed as ‘*kinema-thua-nao-natto triangle*’ [4]. Historically, the preparation and consumption of bacterial-fermented non-salted soybean foods with more to less stickiness, umami flavoured, are exclusively prepared and eaten within these imaginary triangle countries, which has not been reported from any part of the world. Unlike other Asian fermented soybean foods, which are either eaten directly without frying or cooking, e.g. Japanese *natto*, or made into soup or condiments, *kinema*, and other Himalayan fermented soybean foods are made into curry with onion, tomatoes and chillies. Probably, culinary of *kinema* is a blend of Aryan and Mongolian food culture. Though the Eastern Himalayan people have culturally adopted eating soybeans as non-fermented and fermented products, traditionally they never prepare and consume fungal-fermented soybean foods such as *miso*, *soya sauce*, *tofu*, *sufu* and *tempeh*, whereas fermented non-soybean legume products are

limited and are confined only to the Central and Western Himalayas. Black gram is naturally fermented into an artisan spongy ball-like dry product and is called *maseura* in Nepal and *wari* in Himachal Pradesh and Uttarakhand in India. Non-soybean legumes, locally called *dal*, are very popular thick stew eaten with boiled rice and baked bread.

#### Evidence-based traditional practice for soybean fermentation

Extensive research has been conducted to understand the microbial communities, their roles in natural fermentation, nutritional values, health-promoting benefits and the fermentation mechanisms during the traditional methods of preparation of fermented soybean foods of the Eastern Himalayan regions [18–24]. The evidence-based science explains the mechanisms of fermentation during traditional preparation of fermented soybean foods and also validates the commendable indigenous knowledge of ‘ethno-microbiology’ of the ethnic Himalayan people (Table 3) [18, 22, 25–27]. Himalayan fermented soybean foods are rich in microbiome mostly represented by the dominant beneficial and functional bacterium *Bacillus*, which is a rod-shaped, non-pathogenic, showing several bio-functional properties including health benefits such as immunity booster (immunomodulators), antioxidants (anti-cancer), anti-thrombotic (to cure heart disease), and produces vitamins, biopeptides, poly-glutamic acids, etc. [28].

#### Himalayan fermented milk products

Animal husbandry has been a part of traditional agricultural system, depending on the altitudinal-based vegetation for grazing the domesticated animals since the ancient and the medieval times in the Himalayas. Though there is no record of antiquity of origin of the fermented milk products in the Himalayas, preparation and consumption of ethnic Himalayan fermented milk products are observed only among the ethnic communities of the Eastern Himalayas, mostly Darjeeling hills, Arunachal Pradesh and some regions of Assam in India, Nepal, Bhutan and TAR in China, the Central and Western Himalayas (Table 1). Despite the possession of domesticated animals and practising the livestock, historically there is no documentation or record of traditional fermented dairy milk products of some ethnic communities in North-east India mainly Naga, Mizo, Meitei, Apatani, Adi, Mao, Kasi, Garo, etc., of North-east India. This may be due to the Aryan-Hindu pastoral system which might have influenced consumption of milk and milk products in the early settlement in the Himalayas mostly the Central and Western regions. Local varieties and breeds of cows are reared mostly in

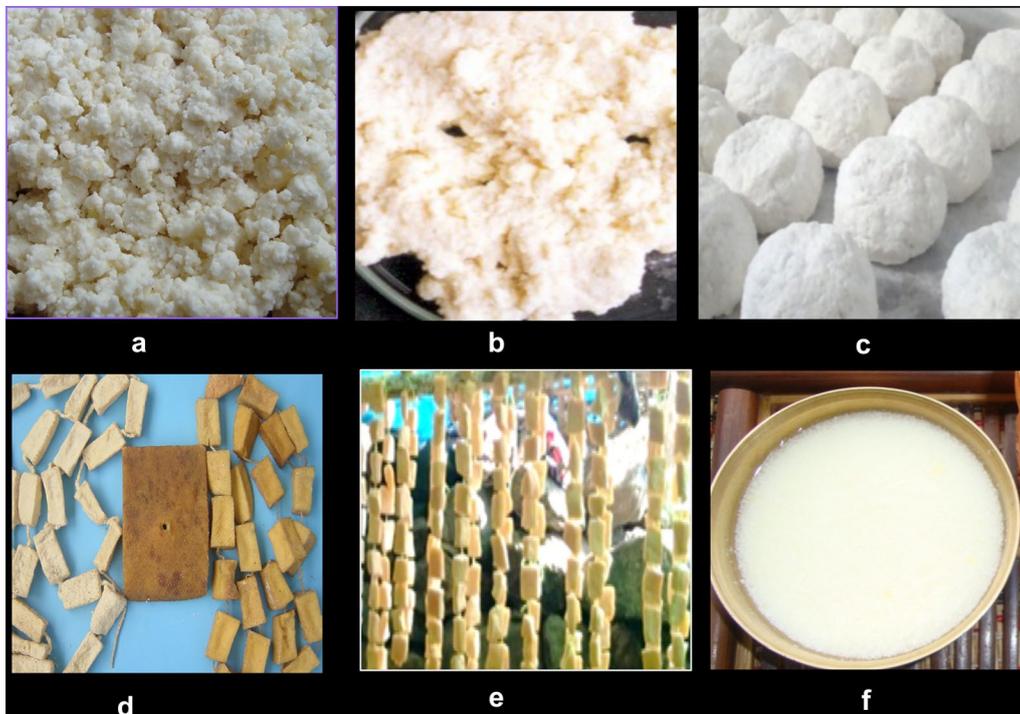
**Table 3** Traditional processing steps during the Himalayan fermented soybean food production with scientific explanation for noteworthy ethno-microbiological knowledge of the Himalayan people

Flow sheet	Details of production steps	Scientific explanation
Soybean ↓ Cleaned and washed ↓ Soaked in water 8–10 h; drained off excess water ↓ ← Added clean water ↓ Cooked in an open cooker ↓ Drained off ↓ Cracked in a wooden mortar lightly by a wooden pestle ↓ Kept in a bamboo basket lined with jute bag and wrapped by fern leaves ↓ Fermented (25–40 °C, 1–3 d) ↓ Sticky fermented soybeans	Soaking of soybeans in water for overnight  Soaked soybean seeds are boiled till it becomes soft  Wrapped in fresh leaves (fern fronds, banana, paddy straw)  Naturally fermented at warm place  Fermented beans are covered with whitish mass, mucilaginous materials if touch appears sticky with umami flavour	Soaking of soybeans will make the seeds soften and also helps to develop some flavour properties [25]  Boiling of soybean reduces the opportunistic and pathogenic microorganisms except heat-tolerant bacteria, and also allergenicity of soybeans [26]  Since the dominant fermentative bacterium is <i>Bacillus</i> which is aerobic to semi-anaerobic, loosely pack leaves or ferns will create the semi-anaerobic condition to facilitate the growth of <i>Bacillus</i> on the surface of fermenting soybeans. [18, 27]  <i>Bacillus</i> is heat resistant and can grow up to 45 °C [27]  Whitish mass is the spores of <i>Bacillus</i> with PGA production which appears as mucilaginous and sticky materials on the surface of soybeans with umami flavour. Flavour is generated during proteolysis (breaking down of protein to amino acids by proteolytic enzymes synthesized by <i>Bacillus</i> spp. during fermentation) [22]

the sub-Himalayan regions, whereas buffalos are reared in the low land hills and *tarai* areas of the Central and Western Himalayas. Yaks (*Bos grannies*) are domesticated in the high lands in Sikkim, Arunachal Pradesh in the Eastern Himalayas, north-west districts of Nepal in the Central and Western Himalayas and Ladakh and TAR in the Western Himalayas. Milk of domesticated animals is traditionally preserved and made into varieties of artisan fermented dairy products by natural fermentation for future consumption [29]. Among the fermented milk products, a soft variety of cottage-cheese-like product known as *chhurpi* (Fig. 3a) is popular among the Nepali/Gorkha, which is consumed as delicious curry or thick soup with cooked rice. Soft variety of *chhurpi* with a short duration of fermentation (24–40 h) is slightly acid in nature, rubbery texture and mild-flavoured, which is mostly preferred by the Nepali/Gorkha consumers, whereas the same product, if kept for a longer fermentation period of more than 7 days, becomes strong-flavoured and highly acidic in nature. Such product is called *chhu* in Sikkim (Fig. 3b) and *datshi* in Bhutan (Fig. 3c) and is mostly preferred by the Bhutia, Tibetans, Dukpa and Ladakhi [30–32]. *Emadatshi* is the popular delicacy in the Bhutanese traditional cuisine prepared from *datchi* and green chillies. Another popular variety of *chhurpi* is a hard-textured, artisan product accordingly designed by the different ethnic communities as per their preferences. Such hard-textured milk product is called *chhurpi* or *dudh chhurpi* (Fig. 3d) by the Nepali/Gorkha and the

Bhutia, *churkam* (Fig. 3e), by the Dukpa of Bhutan and Mongpa of Arunachal Pradesh, *chhura*, by the Ladakhi and *chura loenpa*. Hard-textured artisan *chhurpi* is eaten as a natural chewing gum without any addition of sugar supplements to provide an extra energy to body by continuous movement of jaws and gum of the highlanders Himalayan people. It is a popular milk product in the sub-Himalayan regions too as a masticator. This hard-textured chew-gum-like yak milk product is unique and is innovatively made only in the Himalayan regions; there is no historically correlation of such product with other global milk products.

The yogurt-like curd product commonly called *dahi* (Fig. 3f) also plays a vital role in the Himalayan dietary culture and is religiously considered as a sacred food item by the majority populace of the Hindu and the Buddhists. Highlanders in Sikkim, Arunachal Pradesh, Ladakh in India, Bhutan, northern parts of Nepal and TAR traditionally produce *dahi* from yak milk using their indigenous knowledge. However, in the sub-Himalayan and lowlands, *dahi* is prepared from cow and buffalo milk. Unlike the Balkans and Europeans *yogurt*, *dahi* is also used as non-food items such as to make adhesive coloured spot called ‘tika’ mixed with rice grains and coloured powder to be applied on the foreheads of the family members by the elders during the festivals and marriage ceremonies of the Nepali/Gorkha community as well as hill tribes in Himachal Pradesh and Uttarakhand in India. Such unique application of *dahi* as non-food adhesive for other sociocultural



**Fig. 3** Himalayan fermented milk products: **a** Soft variety of *Chhurpi* of Darjeeling hills, Sikkim and Nepal; **b** *Chhu* of Sikkim; **c** *Datshi* of Bhutan; **d** Hard-variety of *Chhurpi* of Darjeeling hills, Sikkim, Ladakh, Arunachal Pradesh, Nepal, Bhutan and TAR; **e** *Churkam* of Bhutan and Arunachal Pradesh; and **f** *Dahi* of the Himalayas

aspects by the Himalayan people has not been practised by other communities in the Indian subcontinent. *Dahi* is also offered to solemnize the marriage of Hindu and Buddhist.

**Validation of traditional practices for milk fermentation**

Unlike the European yogurt and many fermented milk products, which are produced by controlled fermentation using the standard probiotic starter culture, the Himalayan fermented milk products are still prepared in the traditional way without using any standard starter culture. Ethno-microbiological knowledge of the Himalayan people has been scientifically validated by evidence-based findings. A huge diversity of lactic acid bacteria with probiotic and other biological properties have been reported from various naturally fermented milk products of the Himalayas. These include: *Leuconostoc mesenteroides* subsp. *mesenteroides*, *Leuc. mesenteroides* subsp. *jonggajibkimchii*, *Lactobacillus delbrueckii*, *Lactococcus lactis* subsp. *lactis*, *Lc. lactis* subsp. *cremoris*, *Lc. lactis* subsp. *hordniae*, *Lc. lactis* subsp. *tractae*, *Lactocaseibacillus paracasei* subsp. *tolerans*, *Levilactobacillus brevis*, *Loigolactobacillus coryniformis* subsp. *torquens*, *Lentilactobacillus parabuchneri*, *Enterococcus faecalis*, *E. italicus*, *E. pseudoavium*, *Streptococcus salivarius*, *S. thermophiles*

[30–36]. In vitro and genetic screening of lactic acid bacteria isolated from the Himalayan fermented milk products proved to have probiotic properties such as antimicrobial activities that ensure the safety of the product, reduce serum cholesterol level, making lactose-free fermented milk products for lactose-intolerant consumers, adherence abilities of bacteria to epithelial cells thus contributing the bacterial pathogenesis in the human gut [33, 37]. Though the antiquity and origin of the Himalayan fermented milk products are unknown, the scientific analysis of the traditional fermented milk products has validated the innovative knowledge of the Himalayan people on production of probiotic and functional dietary milk products for nutritional security and health benefits.

**Himalayan fermented vegetable products**

Intake of seasonal vegetables, mostly leafy vegetables and also wild edible herbs, in the daily diets is more common in the subtropical zones rather than temperate zones of the Himalayas. Depending on the altitudinal zones, varieties of leafy and other vegetables are grown for consumption in the sub-Himalayan regions mostly during the winter seasons. Many seasonal fresh leafy vegetables are scanty during the long monsoon seasons in the Himalayas, hence, the people have to depend on

either wild edible plants as vegetable supplements or traditionally fermented vegetable products, which are stored as dry products. Some common fermented vegetable products of the Himalayas are *gundruk* (Fig. 4a); *sinki* (Fig. 4b), *khalpi*, *inziangsang*, etc., which are spontaneously fermented during winter seasons, when the fresh leafy vegetables such as ‘*rayo-sag*’ (*Brassica rapa*), mustard (*Brassica juncea*) leaves and radish (*Raphanus sativus*) leaves are plenty. Unlike other Asian fermented vegetable products such as *kimchi* of Korea and *pao cai* or *suan cai* of China, which are mostly salted and spiced, and consumed immediately after the fermentation without drying or dehydrating, the Himalayan fermented vegetable products such as *gundruk* and *sinki* are non-salted and sun-dried after the fermentation, and the dried fermented vegetables are consumed as soup or curry (Fig. 4c).

Perishable vegetables are fermented naturally by the pit fermentation method which is unique and unparalleled in the Himalayas for biological preservation of perishable vegetables for future consumption. However, the genesis of such a traditional method of pit fermentation in the Himalayas has not been historically documented. Myth and oral history, documented from questionnaire

during the survey narrated by elders of villages, have been recorded on the accidental origin of *gundruk* and *sinki* in Nepal [4]. Ancient and medieval histories of Nepal have seen several wars between small kingdoms prior to unification of modern Nepal [38], which compelled the local villagers to flee their homes. Before fleeing the villages, the wise villagers might have buried all available agricultural produce including freshly grown vegetables in the pits and were covered by mud and hay to hide from the enemies. After the war, the villagers returned back to their homes and started digging out the pits where they have dumped the agricultural produce. Actually, they were looking for food grains, mostly the paddy or maize, and when heaped grains were brought out from pits they pulled some dumped vegetables too. After taking out from the pits, the heaped food grains and vegetables were kept lying on the field in the sun to dry the moist foods grains and also to get rid of unpleasant odour, actually discarding the dumped vegetables. After some time, the villagers went to the pit sites and collected dried food grains and they accidentally noticed the sun-dried leftover vegetables with appealing flavour, and they tasted and found slightly sour with appealing flavour, and they liked the products which were different from the fresh



**Fig. 4** Himalayan fermented vegetable products: **a** *Gundruk* of Darjeeling hills, Sikkim, Assam, Nepal and Bhutan; **b** *Sinki* of Darjeeling hills, Sikkim, Assam, Nepal and Bhutan; **c** *Gundruk* pickle and soup; Himalayan fermented bamboo shoot products: **d** *Mesu* of Darjeeling hills, Sikkim and eastern Nepal; **e** *Soibum* of Manipur; and **f** *Soidon* of Manipur

vegetables and radish. This is how *gundruk* and *sinki* have been accidentally invented in Nepal. Ancient villagers made the sun-dried fermented vegetables into different recipes as per their preferences and started standardizing the traditional methods of mass production of *gundruk* and *sinki*. Accidental invention of *gundruk* might have happened during the rule of Newar, one of the oldest inhabitants of Kathmandu valley in Nepal [39], probably the word *gundruk* might have derived from the Newari word *gunnu* meaning dried taro stalk [4]. The unique type of pit fermentation of vegetables, innovated by the Himalayan people, has not been reported in other parts of the world except in the South Pacific islands and China. Varieties of fermented bamboo shoots are also traditionally prepared and consumed as preserved pickles in the bamboo-growing regions in the Eastern Himalayas such as *mesu* (Fig. 4d) of Sikkim, Darjeeling hills and eastern Nepal, *soibum* (Fig. 4e) and *soidon* (Fig. 4f) of Manipur. Historically consumption and preparation of fermented vegetable and bamboo shoot products is not recorded in the Western Himalayas except in western Nepal (Table 1).

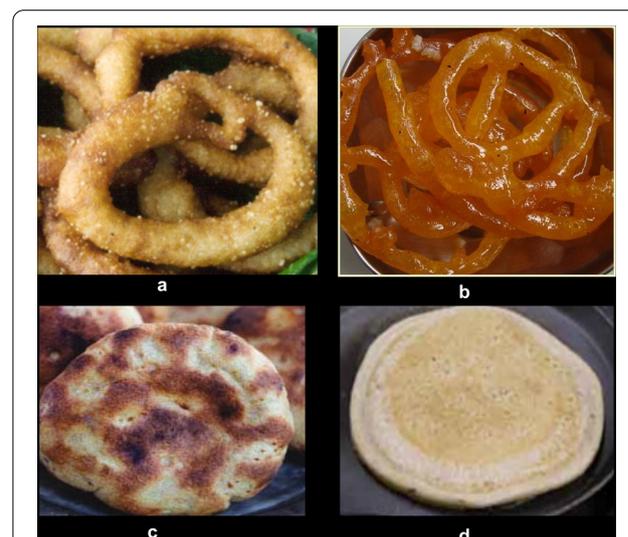
#### Validation of bio-preservation of perishable vegetables

The traditional method of bio-preservation of perishable vegetables by pit fermentation in the Himalayas is actually the lactic acid bacterial fermentation initiated by a consortium of acid-tolerant and carbon dioxide-tolerant (anaerobic condition) bacteria. During preparation, wilted and shredded vegetables or radish are pressed tightly inside the pit dug in the fields. The pressed vegetables are made into heaps in the pit lined with dry bamboo sheaths and rice straw and are covered from top and filled up with mud or cow dung on the surface and also weighted by heavy planks and stones to make it airtight and left for natural fermentation. With their 'ethno-microbiological' knowledge, the ethnic people were 'scientifically' making the anaerobic conditions by making the whole process airtight to facilitate the growth of functional fermenting low acid-tolerant (low pH) and CO<sub>2</sub>-tolerant (anaerobic environment) lactic acid bacteria. These lactic acid bacteria present in *gundruk* and *sinki* fermentation are *Levilactobacillus brevis*, *Lactiplantibacillus plantarum*, *Lacticaseibacillus casei* ssp. *casei*, *Lacticaseibacillus casei* ssp. *pseudoplantarum*, *Limosilactobacillus fermentum*, *Pediococcus pentosaceus* and *P. acidilactici* [40, 41]. During the vegetable fermentation, the carbohydrate present in the vegetables is broken down to glucose by enzymes secreted by the fermenting bacteria for their growth and also lowers the pH to make the product acidic and sour in taste [42]. This will also inhibit the growth of other pathogenic and opportunistic microorganisms and thus making the fermented vegetable

foods safe for consumption. Drying after the fermentation of *gundruk* and *sinki*, is to dehydrate the moisture for prolonging the shelf life of the freshly fermented moist product which can be stored at room temperature for future consumption up to 1 year or more. This is a good example of food preservation in the Himalayas where the majority of rural people cannot afford the cold storage or refrigerator. Himalayan people might have innovated such bio-preservation techniques also to carry the dried products, which are comparatively lighter than the weight of fresh substrates, while travelling for long distances in the difficult terrains of the mountains in ancient times. This ancient habit of carrying sun-dried *gundruk* and *sinki* by the Nepali/Gorkha, while travelling for long distances has become a cultural practice even today. Himalayan fermented vegetables have functional properties and antimicrobial and probiotic properties [43].

#### Fermented cereal products

Cooked rice is a staple cereal diet eaten with varieties of other fermented and non-fermented food items in the sub-Himalayan and low land regions of the Central and Eastern Himalayas. Maize is also a staple diet in the Eastern and Central Himalayas, whereas wheat and barley are the major staple cereal diets in the Western Himalayas. Millets, mostly finger millets and minor millets, are also high mountain cereal crops which are consumed as staple diets in the highlands of the Himalayas including TAR. Traditional fermentation of cereals as food items is rarely seen in the



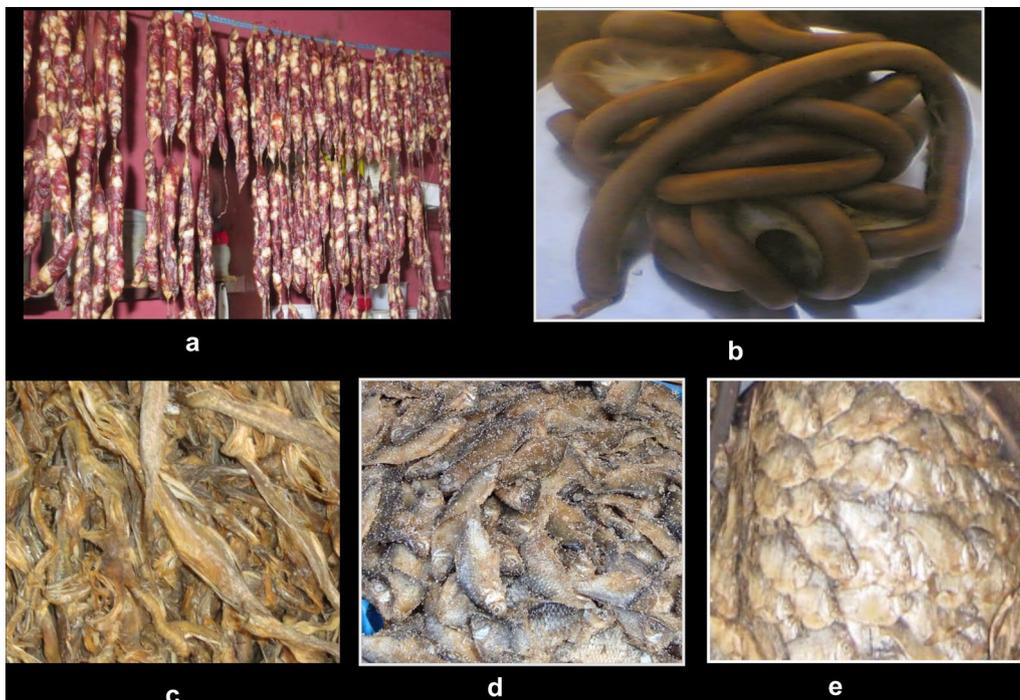
**Fig. 5** Himalayan fermented cereal products: **a** *Selroti* of Darjeeling hills, Sikkim, Assam, Himachal Pradesh, Uttarakhand, Nepal and Bhutan; **b** *Jalebi* of Central and Western Himalayas; **c** *Khambir* of Ladakh; and **d** *Chira* of Himachal Pradesh

Eastern Himalayan regions except *selroti* (Fig. 5a), a ring-shaped deep-fried donut-like confectionary product in Nepal, Darjeeling hills, Sikkim and Bhutan. Rice is commonly fermented into mild alcoholic beverages in North-east India, Nepal and Bhutan in the Eastern Himalayas. Finger millet locally called ‘kodo’ is fermented into mild alcoholic beverages in Central and Eastern Nepal, Darjeeling hills, Sikkim and Arunachal Pradesh in India, and Bhutan. Whereas, a variety of non-alcoholic traditional fermented cereal products are prepared and consumed in the Western Himalayas as staple diets such as *khambir* (Fig. 5b) of Ladakh, *chira* (Fig. 5c) of Himachal Pradesh, etc. Besides edible, some of these ethnic fermented cereal products have ethnic values and are used during festivals and marriages in Himachal Pradesh, Uttarakhand, Kashmir and Ladakh [44]. *Jalebi* (Fig. 5d) is a popular fermented wheat flour mixed with sugar syrup and is deep-fried, circled, and crispy confectionary, in the entire Himalayan region, mostly in the Western Himalayas, except in Ladakh and TAR. Though *jalebi* is of Arabic or Persian origin, it has been known in North India since 1450 CE [45]. *Selroti* is one of the oldest heritage foods with socio-ethical values in the customary life of the Nepali/Gorkha in the Himalayas [46].

**Fermented animal products**

Consumption of beef is a taboo to the Hindu populace in the Himalayas, so as the pork-eating taboo to Muslims. However, traditional preservation mostly by smoking and drying and fermentation of perishable animal flesh is also performed by some ethnic Himalayan communities since immemorable time. The typical Himalayan sausage-like product such as *kargyong* (Fig. 6a) is prepared and consumed in Sikkim, Bhutan, Arunachal Pradesh in the Eastern Himalayas, *gemma* (Fig. 6b) is consumed in Uttarakhand, Ladakh, Himachal Pradesh and TAR in the Western Himalayas (Table 1). Smoked and dried meats are also common in the Himalayas.

Fish-eating culture is traditionally seen in the low lands in the sub-Himalayan regions where ponds, lakes, streams and rivers are located. Salting, drying, smoking and fermentation of locally available freshwater fish are common traditional practices among the different communities in North-east India, east Nepal, and Bhutan in the Eastern Himalayas residing nearby by water bodies and streams/rivers such as *sukuti* (Fig. 6c), *tungtap* (Fig. 6d), *ngari* (Fig. 6e, Table 1). However, such preservation practice of freshwater fish is uncommon in the Central and Western Himalayas. Antiquity of both meat and fish products in the Himalayas are still unknown. The food anthropologist claim that the Asian fermented



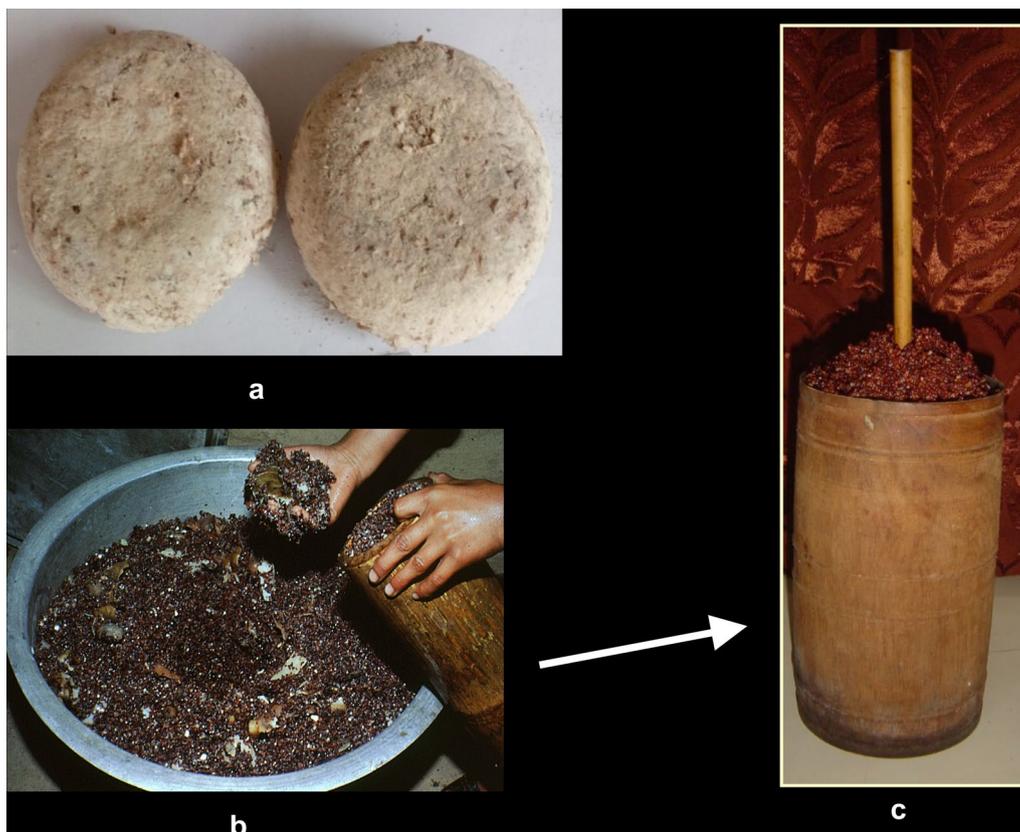
**Fig. 6** Himalayan fermented sausages: **a** *Kargyong* of Eastern Himalayas and **b** *Gemma* of the Western Himalayas. Himalayan fermented sausages: **c** *Sukuti* of the Eastern and Central Himalayas; **d** *Tungtap* of Meghalaya; and **e** *Ngari* of Manipur

fish culture has originated from Makong river basin [47]; however, the traditionally preserved and fermented fish products of South East Asia are different from the Himalayan fish products in terms of traditional processing and mode of consumption. In the Himalayas, preserved and fermented fish are eaten as curry and pickle, however in South East Asia, fermented fish products are mainly made into fish sauce and used as condiments and tastemakers. Recently, a huge microbial community diversity was explored in some traditionally prepared fish and meat products and some of these bacteria have biological functional properties [48, 49]. These traditionally processed fish and meat products are also found safe to eat due to non-production of toxins and absence of some deadly pathogenic bacteria [50, 51].

**Alcoholic fermented beverages**

Alcoholic fermented beverages, mostly prepared from rice, millets and other cereals, and their distilled liquor are culturally and socially used for drinking as well as for worshipping the ancestors and Gods in the Himalayas by the majority of ethnic communities, except the Brahmin

Hindu. Wine-making and also brewing and malting for beer production are historically unknown in the Himalayas, since grapes are not the traditional fruits, except in Himachal Pradesh where grapes have been cultivated since the eighteenth century after the Britishers introduced wine culture in India [52]. Origin and antiquity of the Himalayan alcoholic beverages and use of starter cultures for alcohol production are unknown. Like in many South East Asian countries, alcoholic beverages are traditionally prepared from cereals mostly rice, and finger millets, by mixing with traditionally made non-eatable artisanal starter culture in the form of dry, oval, round, flattened shaped with variable shapes and sizes. Such traditionally prepared starters are known by local names in each locality of the Himalayas (Table 1). *Marcha* (Fig. 7a) is one of the most common starters of the Nepali/Gorkha community which is traditionally used to ferment cereals and millets into alcoholic beverages in Central and Eastern Himalayas regions. Among the Nepali, *marcha*-making hereditary trade is historically confined to the Limboo and Rai castes, both belonging to the Kirat race. *Marcha*-like other community-specific



**Fig. 7** a *Marcha*, an amylolytic starter culture for alcohol production; b fermented finger millets; c *Kodo ko jaanr/chyang*, fermented finger millets, mild alcoholic beverage inside the bamboo-made vessel called ‘toongbaa’ in the Himalayas

starter cultures with different names are also traditionally prepared by other non-Nepali ethnic communities of the Himalayas ranging from Western to the Eastern Himalayas. Conventionally, rice grains are soaked in water for 6–8 h, dewatered and soaked rice grains are crushed in pounded in a wooden mortar by a pestle, then rice flour is mixed with roots and leaves of some locally available wild plants and some spices such as ginger, dry red chilli, and 2–3% of previously made powdered starter, as a mother culture (back-slopping) is added to the mixture. The mixture is then made into thick doughs by adding water and kneaded into different artisanal and variable shapes and sizes, and then they are kept in the fresh fronds of ferns frond/paddy leaves/other leaves on the bamboo stripes, covered by dry ferns and jute bags. Covered doughs are kept at a warm place for fermentation for 2–4 days depending on the seasonal weather of the regions. Swollen appearance of starter culture with mild alcoholic and ester aroma indicates the completion of fermentation. Freshly fermented doughs are taken out from wrapping leaves and are immediately placed in bamboo-made trays for sun-drying for 2–3 days to obtain dry starter culture, which can be stored in a dry condition for a year or more. The general steps followed for the preparation of crude starter cultures among the multi-ethnic people are more or less same, except some variation in wrapping materials, addition of locally available wild herbs and incubation period from region to region in the Himalayas. The artisan starters, innovated by the Himalayan people, are not prepared by every family or community, the production skill is protected among few caste and sub-caste mostly by mountain women who also sell the artisan starters in the local markets for the livelihood and income generation.

The Himalayan alcohol-producing starters, prepared from rice/millet and few wild herbs, are actually the consortia of mixed cultures of saccharifying filamentous moulds [53], amylase and alcohol-producing yeasts [54] and acid-flavour-producing bacteria [55] for the production of alcoholic beverages. The ancient Himalayan people have been cultivating the desirable microorganisms in the form of dry artisan starter where rice serves as the starch-containing base for cultivation of the essential microorganisms. Scientifically, addition of few pinches of powdered starter is to sub-culture or transfer the essential inocula (necessary and functional moulds, yeasts and bacteria) to new starters. Hence, the ethno-microbiological knowledge of the ethnic Himalayan people has been maintaining the functional microbes for long centuries. Several bio-functional properties including probiotics [56] and enzymatic [57] have been reported in the age-old Himalayan artisan starters. Addition of wild herbs during

the preparation actually gives more sweetness (glucose or carbon source) for fermenting microorganisms, and probably the addition is to inhibit the growth of the pathogenic or other unwanted microorganisms during the fermentation.

The traditional preparation methods of the Himalayan dry starter cultures are quite identical to that of dry starter cultures of South East Asia such as *daqu* and *chu* of China and Taiwan, *loogpang* of Thailand, *benh/men* of Vietnam and *dombea* or *medombae* of Cambodia *nuruk* of Korea, *ragi* of Indonesia, *bubod* of Philippines [58, 59]. Some Chinese historians claimed that the first barley-based starter called *chu* was originated in North China in 530–550 CE [4] and rice-based *chu* was originated in South China [60]. Baijii, one of the oldest Chinese alcoholic drinks, is prepared from rice using *daqu*, Chinese artisan starter culture, which was recorded in the second century BCE [61]. Whether *marcha*-making process has independently originated in the Himalayas, or has a historical correlation among the other Asian starters is difficult to establish.

Himalayan artisan starters are used to ferment cereals into different types of thick, mild alcoholic and sweet-sour beverages. Fermented beverages are traditionally distilled to obtain high alcoholic liquor for drinking. Sporadic history on *kodo ko jaanr*, a fermented finger millet mild alcoholic beverage was mentioned during the Kirat dynasty in 625 BCE to 100 CE [62] and also during Malla dynasty in 880 CE [63]. Drinking culture of traditional fermented millet beverages of ethnic people of Darjeeling hills and Sikkim was mentioned in some historical literature works [64–66]. Unlike in other Asian countries, the Nepali, Bhutia, Lepcha, Tibetan, Ladakhi, Mongpa and Dukpa communities of the Himalayas sip the extract of the fermented finger millet beverage locally known as *kodo ko jaanr* or *chyang* (Fig. 7b), which are poured inside an artistically designed vessel, made of up bamboo shoot, called ‘toongbaa’ (Fig. 7c), by a narrow bamboo-made straw. Himalayan beverage is considered as a high-calorie food beverage with a low alcohol content of 4% [67], with bio-availability of minerals [68, 69]. Though origin and history are unknown, it is assured that the Himalayan low alcoholic beverages prepared by using artisan starters contribute high-calorie food beverages and some essential bioactive compounds in the diets of highlander people in adaptation to harsh climatic conditions and deficient of regular food supply. Besides drinking, alcoholic beverages have deep-rooted social values, used to solemnize the marriage ceremony, worship Gods and ancestors, other social functions and festivals and perform spirit possession by some communities.

### How important the Himalayan fermented foods to the diets of the twenty-first century?

The people outside the Himalayan regions may have the curiosity to know how important the Himalayan fermented foods in the context of human health. The Himalayan fermented foods are always considered healthy and nutritive foods. For example, Himalayan fermented soybean foods, such as *kinema* and *hawaijar*, are inexpensive high plant protein foods with several health-promoting benefits such as immunity booster antioxidants (anti-cancer), anti-thrombotic (to cure heart disease), anti-thrombotic properties, anti-diabetic and are rich in vitamins, bioactive peptides, isoflavones, immunomodulators, etc. [28, 70–73]. Himalayan fermented milk products such as *dahi* and *chhurpi* have several probiotic properties [32, 33], biopeptides [74], etc. The consumers of the twenty-first century prefer foods which cure ailments, combat diseases, reduce gut dysbiosis, boost immunity and impart health-promoting benefits. Probably, the Himalayan fermented foods can supplement such demands with high functionalities and health tags to consumers. However, due to popularity and high preference of fast foods and commercially available ready-to-eat foods as well as modernization and urbanization of many regions in the Himalayan countries, the traditional food habits and dietary cultures are affected mostly among the young generations. These changeovers in food habits and more choices of fast foods over ethnic foods may affect the production and consumption of the Himalayan fermented foods and alcoholic fermented beverages. The other reasons may be the climate change which affect the yield and productivity of the agricultural produce and finally may impact the production of traditional fermented foods. Though limited information is available on the impact of climate change on production of Himalayan fermented, Tamang et al. [75] reported the cultural adaption of Himalayan fermented foods to mitigate the harsh climate change in the high mountains.

### Conclusion

Diverse types of exotic, artisan, acidic, alkaline, slow, functional, nutraceutical and fermented foods and alcoholic fermented beverages are traditionally produced by the multiethnic communities of the Himalayan people by their ethno-microbiological knowledge of food fermentation. Some of these fermented foods have been scientifically studied and proved to have several health-promoting benefits to consumers.

Besides delicacy, ethnical and cultural values, the Himalayan fermented foods are also the hubs of biological resources of beneficial and functional microorganisms which have been contributing health-promoting benefits

to thousands of Himalayan people with a dearth of modern food products. Since the Himalayan ethnic fermented foods are region-specific and are mostly based on the traditional knowledge of the ethnic people, the Himalayan people have culturally and historically adopted the consumption of various ethnic fermented foods and alcoholic fermented beverages even in the dearth of modern food supply, hence their traditional knowledge and dietary culture may be preserved with more awareness on the scientific findings on health tags or safety measures of their cultural foods. If so, the importance of regional, traditional, cultural fermented foods and beverages of the Himalayas towards the Sustainable Development Goals of the 2030 Agenda of the United Nations, adopted in 2015 may suffice and create an example of sustainable cultural food and nutritional security. The novelty of this study is the documentation on validation of the traditional practices of some common Himalayan fermented foods by scientific evidence, which have been extensively studied earlier. However, the limitation of this study is tracing back the origin and history of the Himalayan fermented foods and alcoholic fermented beverages due to a dearth of archaeological findings, historical monuments and chronological records of the ethnicity in the Himalayas and the unavailability of food anthropological studies. When and how the Himalayan fermented foods and alcoholic beverages originated are still unknown.

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### Author contributions

The paper was written by me. The author read and approved the final manuscript.

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### Ethics approval and consent to participate

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