



Diversity of Ethnic Smoked Food Products of Eastern Himalayan Region: A Review

G. Kadirvel¹, Thameridus B. Marak², Robin Subba³, Ajita Tiwari², Aniruddha Roy⁴, Angam Raleng³, Bansaramaphi Jana⁴, Heikham Naresh Singh⁴

10.18805/ajdr.DR-2249

ABSTRACT

The Himalayan food demography is a diverse resulting combination of the multi ethnic and multi-regional variations of the Hindu-Aryan and the Buddhist-Mongolian culture surrounding the area. The region's food habit consists of smoked, dried and preserved food products. Their unique method of food preparation by using smoke has become an identifiable characteristic of their food culture. Studying these products can help to identify their market potential. This paper reviews the range of food products in the Eastern Himalayan region that are prepared by the method of smoke exposure, the benefits of consuming these smoked meat items, the proper procedure that should be taken in smoking of any food products and the modern scientific interventions that have come up in these modern times to make the smoking procedure easier and safer. The paper also studies the commercialization constraints faced in promoting these products to a global front and the strategies that can be adopted to overcome these constraints. The review highlights the nutritional, sensory and preservation advantages of the many ethnic smoked food products found in the Eastern Himalayan region. It analyzes both conventional and contemporary smoking methods, points out obstacles to commercialization and offers solutions including infrastructure development, market promotion and training to increase their economic potential and worldwide reach.

Key words: Eastern himalayan region, Ethnic, Smoked food, Smoked products.

Eastern Himalayan Region (EHR) consists of India, Bhutan, Nepal, Myanmar and a part of Tibet. In India it consists of the northern extent of West Bengal including Darjeeling District and the northeastern Indian states of Assam, Arunachal Pradesh, Manipur, Mizoram, Tripura, Meghalaya, Nagaland and Sikkim. Unlike the rest of the world, this region has a distinct topography and is inhabited by a large number of ethnic tribes with distinct food demography. Approximately, 200 ethnic tribes dominate this region making the overall population of 65 million people (Sharma *et al.*, 2006). Food demography in this region is different from other parts of the world as irrigation is limited due to harsh geographic condition so people have to depend on meat and meat products as a source of protein (Tamang, 2010). The EHR due to its altitude has difficulty in much food accessibility. Staple Food items like Rice, Wheat and Maize can only grow in lower regions up to an elevation of 2400 meters. Beyond 2500 meters, only Potato, Barley, Finger Millets can be grown. Similarly, milk from cows and buffalos are accessible only in regions up to a height of 2400 whereas regions beyond this altitude usually derive milk and its products from Yak. Legumes, Seasonal vegetables are also difficult to grow in high terrain regions.

Every ethnic group in the Eastern Himalayan region have their own unique method of food preparation due to geographic, religious and distinct cultural traditions that have influenced the food consumption habits of the population. This region has a wide range of ethnic foods made up of traditional herbs and vegetables including soybean, bamboo shoots, tree bean, *etc.* (Kadirvel *et al.*, 2018). Meat, fish and vegetables in smoked, dried and

¹ICAR-Agricultural Technology Application Research Institute, Guwahati-781 017, Assam, India.

²Department of Agricultural Engineering, Assam University, Silchar-788 011, Assam, India.

³College of Agricultural Engineering and Post Harvest Technology, Central Agricultural University, Gangtok-737 135, Sikkim, India.

⁴ICAR Research Complex for North Eastern Hill Region, Umiam-793 103, Meghalaya, India.

Corresponding Author: Thameridus B. Marak, Department of Agricultural Engineering, Assam University, Silchar-788 011, Assam, India. Email: thameri.marak@gmail.com

How to cite this article: Kadirvel, G., Marak, T.B., Subba, R., Tiwari, A., Roy, A., Raleng, A., Jana, B. and Singh, H.N. (2025). Diversity of Ethnic Smoked Food Products of Eastern Himalayan Region: A Review. Asian Journal of Dairy and Food Research. 1-10. doi: 10.18805/ajdr.DR-2249.

Submitted: 01-07-2024 **Accepted:** 01-04-2025 **Online:** 14-05-2025

fermented form is constantly included in the regular diet of the people of the region. Smoked food is one of the major traditionally prepared and consumed habits by the ethnic groups of this region.

The practise of smoking food is an old process. It is thought to have been developed as an adjunct to the drying method of preserving meat and fish by hanging the product over a fire or in a room in which a fire was maintained for warmth or cooking purposes. Traditional smoking techniques involves treating of pre-salted, meat/fish/vegetables with wood smoke. Hard-smoked, highly salted items pose minimal to no risk to public health since their

water content is too low to encourage microbial development (Bolaji *et al.*, 2022). The product to be dried is hung over the bonfire, when the hot smoke comes in contact with the product, the moisture gets reduced which results in the microbial stability of the product and also prolongs its shelf life, enhances its flavor and texture (Sikorski and Ko³akowski, 2010). In addition to the preservation by dehydration, the bacterial and antioxidant properties of the smoke also increases the storage stability of the treated smoked product (Bratzler *et al.*, 1969).

Although smoked food products have good nutritional value but not enough commercialization is done at a worldwide level. Despite their healthy and nutritionally beneficial values, these items are not as popular in the rest of India as it is among the ethnic groups of EHR. The potential of traditional smoked products should be explored since these products developed by different ethnic groups have lots of variations in their preparation with no standard protocol for preparation, smoking level or time, scientific validation and optimization, labeling, packaging or commercialization. Therefore, this paper aims to enumerate the different types of smoked food product, its specialty and constringes. Accordingly, the paper suggests scientific intervention for commercialization of the suggested traditionally smoked product in the region.

Advantages of smoked food products

Smoked food has numerous characteristics such as intense flavor, colour and texture which have always made it a delicacy along with its additional benefits of microbiologically stable with lower bacterial count and higher self-life (Goulas and Kontominas, 2005). Phenolic antioxidant compound present in smoke prevents lipid oxidation resulting in higher sensory acceptability of smoked products (Toth and Potthast, 1984). Several advantages of smoking process include.

Preservation

Smoked foods are preserved due to the presence of phenolic compounds and formaldehyde. These compounds are well known for their anti-microbial activities. Exposure of food products to smoke results in preservation of food items by preventing growth of surface molds and bacteria. Addition of smoke emits various acids which clings to the outer surface of food and helps in coagulation of the surface (Tilgner, 1976).

Enhanced aroma and flavor

Smoking of food results in enhancing the flavor due to the presence of phenols, carbonyl compounds and organic acids. Various research conducted in meat and fish value added products prepared by adding liquid smoke at 0.1% and 0.5% concentrations reported to have enhanced sensory attributes (Emine and Bahri, 2017; Ahlawat *et al.*, 2012).

Develop appealing color

In case of meat and fish products, carbonyl compounds combine with free amino groups reacts with meat and fish

protein to form furfural compounds that are brown in color and translucent. These when added with the reddish color of the cooked cured meat, a reddish brown color is developed (Maga, 1987).

Protection from oxidation

Smoking results in preventing food from lipid oxidation which in result eliminates the stale taste of fat (Messina *et al.*, 1988).

Formation of a protective layer

Smoking results in formation of acids through smoke which helps in coagulating the protein on the surface of the meat/ fish products (Messina *et al.*, 1988).

Methods of smoking techniques

Mechanism of smoking as a means of preservation

There are several ways that smoke is preserved, but the main ones include antibacterial, antioxidant and drying properties. Because they break down bacterial cell membranes and stop their metabolism, smoke's phenolic compounds-such as catechol and guaiacol-have potent antibacterial properties. By fostering an environment that is not conducive to microbial growth, smoke's aldehydes and organic acids-such as formaldehyde and acetic acid-help to limit microbial growth. Smoke also contains antioxidants that prolong food's shelf life by preventing lipid oxidation. Smoking's drying effect limits the growth of microorganisms by lowering water activity.

The traditional method

Traditional smoking involves partially thermally decomposing wood to produce smoke, which preserves food and enhances its flavour (Fig 1). This process produces a mixture of gases, vapors and solid particles, with phenols, organic acids and carbonyls in smoke. It helps prolong food product shelf life by inhibiting microbial development, lipid oxidation and spoiling. Smoking can be divided into hot and cold smoking, with hot smoking cooking food at higher temperatures (55°C and 80°C) ensuring a unique texture and flavor while ensuring microbiological safety. Scientific advancements have improved traditional smoking methods, ensuring cultural value while optimizing quality and safety (Vaz-Velho, 2003).



Source: Marianski *et al.*, 2012.

Fig 1: Traditional method of smoking fish.

Cold smoking

Cold smoking is a low-temperature method used to achieve a smoky flavor without cooking food. It involves controlling the temperature between 15°C and 25°C, either by controlling airflow or cooling the smoke before contact with the food. Cold smoking times can vary depending on the food variety, desired flavor and preservation needs. It improves flavor, aroma and preservation while preserving the texture of raw or partially processed food. Cold smoking can be used on a wide range of foods, including smoking of cheese, raw ham, bacon, salami and dried sausages (Fig 2). Controlling smoke movement is crucial for dried goods to prevent crust formation and maintain moisture loss. Cold smoking is a popular technique in both conventional and commercial food processing, producing flavorful and long-lasting smoked meals (Woods, 2003).

Hot smoking

Hot smoking is a method of cooking and flavoring food at high temperatures, typically between 55°C and 80°C. This technique is used in both traditional and commercial food processing to create unique smoky flavors, enticing textures and long shelf life. A subset called moist smoking is used, where the smoke temperature is maintained between 24°C and 48°C with higher relative humidity. This helps prevent food from drying out and provides a softer, more juicy texture. Popular hot-smoked foods include cooked ham, frankfurters, salami and cocktail sausages. The operating temperature depends on factors like food type, desired texture and flavor profile and food safety concerns. Proper temperature control ensures efficient microbial elimination, reducing contamination and spoilage. Hot smoking remains the preferred method for creating safe, tasty and ready-to-eat smoked food products with a balance of flavor, texture and preservation benefits (Woods, 2003).

Electrostatic smoking

Electrostatic smoking is a method that uses electrically charged smoke particles to apply smoky ingredients to food surfaces. It involves placing food items between live electrical wires charged between 20 and 60 kV in a tunnel-style smoking chamber (Fig 3). This method improves the rate and consistency of smoke deposition, leading to a more consistent flavor, color and preservation effect than standard smoking techniques. The ionized smoke particles attract organic acids, carbonyls and phenolic chemicals, giving the meal its unique smoky flavor and antibacterial qualities. This method is efficient and reduces smoking time. The food product often undergoes an extra phase of infrared (IR) irradiation after deposition, ensuring optimal smoke absorption, improved shelf life and enhanced microbiological stability. Electrostatic smoking is widely used in industrial food processing for high-quality smoked goods with shorter processing times and better flavor retention (Woods, 2003).

Liquid smoke

Liquid smoke technology is a modern method of capturing and using natural smoke in a more regulated and adaptable way. This method involves condensation of smoke from a traditional smoke generator and processing it into liquid, organic or powdered forms. This method offers smoky flavors and preservation advantages without exposing food to charcoal or burning wood. Liquid smoke is hygienic, reliable and sustainable and can be produced in various forms, such as an aqueous solution, an organic solution, or a dry powder. It provides more control over taste strength, enhanced safety and wider use in food production. It allows food processors to mimic smoky flavors without the challenges of maintaining clean smoking chambers or managing airflow. Techniques like spraying, dipping, or direct mixing with food recipes can be used to apply liquid smoke evenly and effectively. This method ensures consistent quality and flavor while adhering to food safety regulations (Woods, 2003).

Ethnic smoked products of HER

Table 1 shows the nutritional factors of various smoked products of the Eastern Himalayan Region. This region



Source: Marianski *et al.*, 2012.

Fig 2: Cold smoking of chesse.



Source: Marianski *et al.*, 2012.

Fig 3: Electrostatic smoking of fish.

Table 1: Ethnic smoked and fermented food products of eastern himalayan region.

Products	Local/ Common name	Origin/Mostly consumed in	Nutritional factors	References
Smoked meat products	Karyong	Bhutan, Nepal, Tibet, Sikkim, Darjeeling	Protein: 16.0%, Fat: 49.1%, Carbohydrate: 32.0% and Food value: 634.5 kcal/100 gm	Rai <i>et al.</i> , 2009
	Lang karyong	Tibet, Nepal, Sikkim, Darjeeling, Ladak, Bhutan	Moisture: 59.8%, Protein: 8.4%, Fat: 10.3%, Carbohydrate: 77.5%, Ash: 3.8%, Energy: 436.2 kcal/100 g	Rai <i>et al.</i> , 2010
	Yak karyong	Bhutan, Tibet	Moisture: 21.9%, Ash: 2.8%, Fat: 49.1%, Protein: 16.0%, Carbohydrate: 32.0%, Energy: 634.5 kcal/100g	Rai <i>et al.</i> , 2010
	Faakkaryong	Nepal, Sikkim, Darjeeling, Ladak, Bhutan, Tibet	Moisture: 41.0%, Ash: 2.8%, Fat: 27.1%, Protein: 11.5%, Carbohydrate: 58.6%, Energy: 501.4 kcal/100 g	Rai <i>et al.</i> , 2010
	Lang satchu	Tibet	Moisture: 22.8% Ash: 5.4%, Fat: 5.9%, Protein: 57.7%, Carbohydrate: 31.0%, Energy: 407.7 kcal/100 g	Rai <i>et al.</i> , 2010
	Arjia	Kumaon Himalayas	Moisture- 60.2±0.2% Ash- 3.5±0.4% Fat- 5.5±0.4% Protein- 6.4±0.9% Carbohydrate- 84.6±.7% Energy- 413.5±1.2 kcal/100 g	Rai <i>et al.</i> , 2010
	Satchu	Tibet	Fat: 4.7% Protein: 51.0%, Carbohydrate: 37.0% and Food value: 405.8 kcal/100 gm	Rai <i>et al.</i> , 2009
Smoked vegetable	Akhuni	Northeasten states of India	Protein: 41.1%, Crude fiber: 1.61%, Reducing sugar: 29.7% Total phenolic content: 0.86 mg GAE/g, Total flavonoid content: 0.64 mg QE/g	Jamir and Deb, 2018
Smoked fish product	Sukuti	Nepal, Sikkim, Darjeeling	Protein: 35.0%, Fat: 12.0%, Carbohydrate: 36.8%, Food value: 395.2 kcal/100 gm, Ca: 38.7 mg/100 gm, Fe: 0.8 mg/100 gm, Mg: 5.0 mg/100 gm, Mn: 1.0 mg/100 gm and Zn: 5.2 mg/100 gm	Thapa <i>et al.</i> , 2007; Thapa <i>et al.</i> , 2006
	Suka ko maacha	Nepal, Sikkim, Darjeeling	Protein: 35.0%, Fat: 12.0%, Carbohydrate: 36.8%, Food value: 395.2 kcal/100 gm, Ca: 38.7 mg/100 gm, Fe: 0.8 mg/100 gm, Mg: 5.0 mg/100 gm, Mn: 1.0 mg/100 gm and Zn: 5.2 mg/100 gm	Das <i>et al.</i> , 2016
	Ngari	Manipur	Protein: 34.1%, Fat: 13.2%, Carbohydrate: 31.6%, Food value: 381.6 kcal/100 gm, Ca: 41.7 mg/100 gm, Fe: 0.9 mg/100 gm, Mg: 0.8 mg/100 gm, Mn: 0.6 mg/100 gm and Zn: 1.7 mg/100 gm	Thapa <i>et al.</i> , 2004; Thapa <i>et al.</i> , 2007
Smoked beverages	Bhati jaar	Nepal, Sikkim, Darjeeling	Protein: 9.5%, Fat: 2.0%, Crude fiber: 1.5%, Carbohydrate: 86.9%, Food value: 404.1 kcal/100 gm, Ca: 12.8 mg/100 gm, K: 146.0 mg/100 gm, P: 595.0 mg/100 gm, Fe: 7.7 mg/100 gm, Mg: 50.0 mg/100 gm, Mn: 1.4 mg/100 gm and Zn: 2.7 mg/100 gm	Tamang and Thapa, 2006
	Kodo ko jhaar	Nepal, Sikkim, Darjeeling	Protein: 9.3%, Fat: 2.0%, Crude fiber: 4.7%, Carbohydrate: 83.7%, Food value: 389.6	Thapa <i>et al.</i> , 2006

Table 1: Continue....

Table 1: Continue....

	Apong	Arunachal Pradesh, Assam	kcal/100 gm, Ca: 281.0 mg/100 gm, K: 398.0 mg/100 gm, P: 326.0 mg/100 gm, Fe: 24.0 mg/100 gm, Mg: 118.0 mg/100 gm, Mn: 9.0 mg/100 gm and Zn: 1.2 mg/100 gm Moisture content: 87-90%, Acidity: 1.03-1.04, Alcohol: 4.2-5.5%, Carbohydrate: 7.0-8.5g/100 g, Ash: 0.1-0.3 g/100 g and Reducing sugar 5.1-6.0% [126]	Shrivastava <i>et al.</i> , 2015
Smoked dairy products	Churpi	Bhutan, Nepal, Sikkim, Darjeeling	Protein: 65.3%, Fat: 11.8%, Carbohydrate: 16.3%, Ca: 44.1 mg/100 gm, Fe: 1.2 mg/100 gm, Mg: 16.7 mg/100 gm, Mn: 0.6 mg/100 gm and Zn: 25.1 mg/100 gm	Dewan, 2002; Tamang and Tamang, 2010

with its diverse culture and geography has notable smoked food products which are described below.

Smoked meat

Smoked meat is one of the major traditionally prepared and consumed meat products of the ethnic groups of the EHR. Smoked meat is famous among certain parts of the world like the ethnic Sikam Paa in Bhutan, Yak karyong in Nepal, Satchu in Tibet, Sukakomasu and Sukuti in Sikkim (India), Kathee and Tarfa-Gara in Maynama, Lang satchu in Tibet (China) (Rai *et al.*, 2009), Hangikjot in Iceland (Steingrimsdóttir *et al.*, 2018), Jerky or Charqui in South America (Fadda and Vignolo, 2014) and Merdouma/bourdime/mandi in North Africa (Salloum and Lim, 2012) are being prepared traditionally and consumed as a ready to eat meat. Traditional smoking techniques involve treating of pre-salted meat product with wood smoke. The product to be dried is hung over the bonfire, when the hot smoke comes in contact with the product the moisture gets reduced which results in the microbial stability of the product and also prolongs shelf life, enhances flavor and texture (Sikorski and Kołakowski, 2010).

Smoked pork product

Dohtrykhong

It is an important ethnic food of Meghalaya particularly made of pork, prepared by cutting the meat into stripes of 20-25 cm and then marinating thoroughly with salt, mustard oil and turmeric powder. Smoking is carried out traditionally in earthen kitchen oven for 4-6 days. This smoked meat product can be stored at room temperature for several weeks (Kadirvel *et al.*, 2018).

Faak karyong

It is the traditional sausage like product prepared from minced pork meat and fat mixed with salt, garlic paste, water and ginger paste. The gastro-intestinal tract of pig also known as gyuma is used to stuff the mixture of minced meat and spice ingredients. The casing of intestine used for Faak karyong is of 3-4 cm in diameter and 40-60 cm long. The Mixture is filled from one end while the other end of the casing is tied with a thread and then boiled for 20 to

30 min. Drying and smoking of cooked sausages is carried out for 10 to 15 days by hanging above the earthen oven in kitchen. The curry of Faak karyong is prepared by frying with ground chillies, salt, onion and tomatoes. Sherpa, Drupka, Nepali, Tibetans, Lepcha and Bhutia people residing in the hilly region of Darjeeling, Ladak and Sikkim of India, Nepal, Tibet and Bhutan are familiar with the product (Rai *et al.*, 2009).

Smoked beef/yak product

Lang/Yak Karyong

Lang/Yak Karyong is the traditional sausage like product prepared from minced beef/yak meat and fat mixed with salt, garlic paste, water and ginger paste. The gastro-intestinal tract of a cow is used to stuff the mixture of minced meat and spice ingredients. The casing of the intestine used for Lang/yak karyong is of 3-4 cm in diameter and 40-60 cm long. Mixture is filled from one end while the other end is tied with a thread and then boiled for 20 to 30 min. Drying and smoking of cooked sausages is then carried out for 10 to 15 days by hanging above an earthen oven in the kitchen. The curry of Lang/yak karyong is prepared by frying with ground chillies, salt, onion and tomatoes. Mostly Sherpa, Drupka, Nepali, Tibetans, Lepcha and Bhutia people residing in the hilly region of Darjeeling, Ladak and Sikkim of India, Nepal, Tibet and Bhutan are familiar with the product (Rai *et al.*, 2009).

Satchu

Satchu is the smoked or dried traditional product of Sherpa, Drupka, Nepali, Tibetans, Lepcha and Bhutia people residing in the hilly regions of Darjeeling, Ladak and Sikkim of India, Nepal, Tibet and Bhutan prepared from mostly beef/yak meat. A 60-90 cm long red meat of beef/yak is sliced into a cylindrical shape and thoroughly mixed with edible oil (mustard oil), salt and turmeric powder. Wooden stick or bamboo stripes are used to hang the sliced meat and kept above the earthen oven in kitchen for smoking for 10-15 day. Generally, curry of satchu is prepared by frying in yak/cow butter with chili, salt, ginger, chopped garlic and onion. Two types of satchu viz., Lang satchu (made from

beef) and Yak satchu (prepared from yak meat) are being prepared commonly by these ethnic tribes (Rai *et al.*, 2009).

Smoked mutton

Chartayshya

It is smoked or dried traditional product consumed by the Bhutia people of Kumaon Himalayas, particularly the Munsiairy and Dharchula region of Pithoregarh district. Chartayshya is very similar to satchu in the process of smoking but differs in the type and size of animal meat used. Goat meat is cut into 3-4 cm in size and mixed with salt. With the help of a thread, the meat is sown in rows and placed above the earthen oven in kitchen for smoking for 15-20 days. This product can be kept for several weeks without preservatives at room temperature (Rai *et al.*, 2009).

Sukha sikharis

It is similar product as chartayshya prepared from chevon by the ethnic people of western Nepal. Generally, curry of satchu is prepared by frying in edible oil with chili, salt, ginger, garlic and onion. Kumaun Himalays people celebrate kolatch festival where they prepare the chartayshya and sukha sikharis as an offering for their ancestral spirit (Rai *et al.*, 2009).

Arjia

It is a smoked or dried traditional sausage product from Kumaon Himalayas in Northern India consumed by the Bhutia people. Arjia is similar to jamma in the preparation method. Minced lung of goat is mixed with fresh animal blood, chilli powder, wild pepper (timbur) and salt. Stuffing is done in the large intestine of goat where as in case of jamma small intestine is use. It is the boiled for 15-20 min and then placed above the oven for smoking for 15-20 days. Generally, curry of Arija is prepared and consumed along with the meal (Rai *et al.*, 2009).

Smoked fish product

Nga-Ayaiba of Manipur is prepared by drying and smoking. Its processing is one of the oldest economical and traditional methods for the production and preservation of fishes (Meitei and Singh, 2018). Perungo (Sukakomaacha) is the traditional smoked fish product prepared by the ethnic people of hilly region especially Sikkim, Nepal and Bhutan. The spices of such as chuchayasala (*Schizothorax progastus* Mc Clelland) and dothayasala (*Schizothorax richardsoni* Gray) are generally used for making Sukako maacha. The fish is spread over a bamboo basket placed above the earthen cooking oven for 7 to 10 days. This smoked fish product can be preserved for 4 to 6 months (Rapsang *et al.*, 2011).

Smoked insects

Asian dune crickets of the species *Schizodactylus monstrosus* (Schizodactylidae) are the most highly valued food insect among the Galo tribes of Arunachal Pradesh. Freshly collected specimens are put inside a bamboo pipe and

smoked dry for nearly one week. Completely dried material is then crushed into a powder and mixed with chili peppers, salt and bamboo shoots to form a special type of chutney. This chutney is taken with rice or with local drinks known as Apung and is regarded as most delicious by all members of the tribe irrespective of age and sex (Chakravorty *et al.*, 2011). Smoking rice grasshoppers are very common among the ethnic tribes of Karbi Anglong District in Assam. Both nymph and adult insects are smoked and consumed as chutney or in fried form (Chowdhury *et al.*, 2015).

Smoked vegetarian dishes

Yanniperung

The Soybean based fermented and smoked product, called yanni perung is very popular among the Apatani tribe in Lower Subansiri district in Arunachal Pradesh. To process it, seeds are cleaned, washed and boiled in water for about 30 min. The boiled seeds are packed airtight in kulu leaves (wild banana) and kept on top of the fire place area for smoking. During summer, the seeds get fermented and smoked within 3-4 days while in winter it takes about 10-12 days giving the smoky fermented taste. These fermented and smoked seeds are then consumed as chutney. It can be preserved for over several months after drying and made into a paste with red chilli and dried ginger (Singh and Singh, 2007).

Hakhumata/akhuni

This product is very famous among the Naga tribes. It is prepared using soybean seeds. The soybean seeds are properly dried in partial shade and for about half an hour. Boiled seeds are left upon the bamboo made sieves to drain off the water and then placed on the cotton cloth allowing it to dry partially in the shade. The dried seeds are wrapped in banana leaves and hung above the fireplace using bamboo ropes to allow smoking and fermentation. The complete process takes place in about 15-20 days in winter and 5-7 days in summer. When the leaf of banana becomes completely wrinkled, it indicates that the process of fermentation is complete. The seeds are taken out from leaves and roasted with salt without any oil. These seeds are again packed in fresh banana leaves and stacked over the shelf near smoke in kitchen. After 3-5 days this is ready to eat and sale (Singh and Singh, 2007).

Anthur rep (dried/smoked roselle)

In Mizoram, the sun-dried or smoked Roselle is locally known as anthur rep and is used for seasoning vegetables, fish and meat curries. It is well known for having therapeutic properties and has been used in folk medicine as a diuretic, mild laxative and for the treatment of kidney, cardiac and liver diseases, hypertension, pyrexia and skin inflammations (Riaz and Chopra, 2018).

Smoked beverages

In contrast to other smoked foods, the aim of smoking in beverage production has not traditionally been to prolong shelf life but to flavor the drink (Gogoi *et al.*, 2013).

Chu bitchi

Chu bitchi is a smoked and fermented rice beer most commonly prepared and consumed by the Garo tribes of Meghalaya. The starter culture is made up of a mixture of menil (stick rice) and red chillies. During the fermentation process, charcoal blocks from the fireplace are put into the rice dough mixed with starter and wrapped in banana leaves for generating a smoky flavor. These packets are kept in a perforated bamboo basket perforated with uniform holes throughout its body which is placed at the center of an earthen pot. The entire pot will be tied and covered with ficus/banana leaves and kept above a fireplace for 15-20 days (Mishra *et al.*, 2021).

Apong

Apong is prepared by the Mising tribe of Upper Assam and the starter cake used to prepare this beverage is called as aopopitha. Apong has a sweet, malty and spicy taste with smoky flavor and it forms an integral part of the culture, traditions and rituals of this tribe (Gogoi *et al.*, 2013). It is at least a 3-month process that includes drying, smoking, fermenting, filtering and finally the concoction is drunk out of a bamboo shoot. The starter culture is prepared by soaking rice in water for 2 hours with addition of roots leaves and bark of wild plant species. It is then grounded into a powder form and mixed with an old epopculture, kneaded to a cake and covered with fresh ferns and dry rice straw. The epop is then fermented at 30°C to 35°C in bamboo tray and kept over a fire place for 3-5 days. After the epop is ready, it is then used for fermentation of cooked rice. The cooked rice, rice husk and the ash powder of straw is mixed and kept in a dry container. Fermentation is allowed for 20 days at 30°C-35°C. This beverage is known to be used in various ailments including dysentery and body pain and known to be helps in increasing the perspiration and thereby releasing the extra heat from the body (Kardong *et al.*, 2012).

Smoked diary products

Churpi

Churpi is a popular traditional milk product in several countries of the Indian subcontinent having moderate sweet and smoky flavour. It is prepared by acid and heat coagulation of defatted (made by using a bamboo churn) milk (Hossain *et al.*, 1999). The curd is pressed for 2-3 days and the cut into pieces are dried for 1-2 days, the pre churpi is then dipped in a hot milk-sugar solution. The cooked product is dried over a wood fire for 25-30 days (Hossain *et al.*, 1999).

Modern Scientific Interventions for smoking process

Smoking gun

Smoking gun/food smoker is often used to add natural cold smoke flavor and aroma to meat, fish, vegetables, sauces and cocktails without using heat. The gun has a wood chamber on top and a tube coming out of the barrel (Fig 4). Wood chips can be kept in through the chamber

and ignited. The tube should be pointed toward the food items. The food is covered to trap the smoke within the food or drink and allow it to sit for a few minutes to let the smoky flavors absorb into the food.

Propane/Gas smokers

A propane smoker is designed to allow the smoking of food in temperature controlled environment. The primary differences with smoke gun are the sources of heat and of the smoke. In a propane smoker, the heat gets generated through a gas burner under a steel or iron box containing the wood or charcoal to provide smoke (Fig 5). The steel box has few vent holes, on the top of the box only. By starving the heated wood of oxygen, it smokes instead of burning.

Commercial smoke houses

Commercial smoke houses are made up of stainless steel having independent systems for smoke generation and cooking. Smoke generators use friction, an electric coil or a small flame to ignite sawdust on demand. Heat from steam coils or gas flames is balanced with live steam or



Source: Marianski *et al.*, 2012; Smoking (Cooking), Wikipedia.

Fig 4: Smoking gun.



Source: Marianski *et al.*, 2012; Smoking (Cooking), Wikipedia.

Fig 5: Propane or gas smoker.

water sprays to control the temperature and humidity. Elaborate air handling systems reduce hot or cold spots and results in uniformed finished product. The products are held on racks having wheels or rails which facilitate movement.

Offset smokers

Offset smoker consists of two cylindrical shaped cooking chambers having the shorter and smaller one attached to the bottom of one end for a firebox (Fig 6). To smoke the food products, a small fire is lit in the firebox, where airflow is tightly controlled. The heat and smoke from the fire are drawn through a connecting pipe or opening into the cooking chamber.

Electric smokers

Electrical smokers are considered as one of the most convenient of the various types of smokers (Fig 7). It consists of a heating element having the facility to maintain temperature range required for cold smoke and can go up to 135°C (275°F). This equipment requires little to no intervention from the user.

Smoke box

Smoke box consists of two-box system viz., a fire box and a food box (Fig 8). The fire box has the provision to be controlled to a finer degree and is placed adjacent or under the cooking box. The food is cooked and smoked in the cooking box through the heat and smoke exhausted from the fire box. These may be as simple as an electric heating element with a pan of wood chips placed on it, although more advanced models have finer temperature controls.

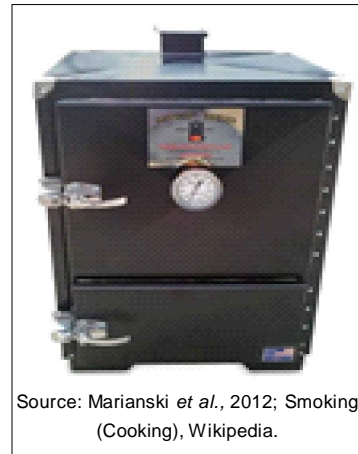
Vertical water smoker

Vertical water smoker is a variation of upright drum smoker and is also known as bullet smoker. It consists of a water bowl placed between the fire and cooking grates and uses charcoal or wood to generate smoke and heat (Fig 9). The main purpose of the water bowl is to maintain optimal smoking temperatures and add humidity to the smoke chamber. Inside this smoker, an effect is created where the water vapor and smoke condense together resulting in addition of smoky flavors to the food. Vertical water smokers



Source: Marianski *et al.*, 2012; Smoking (Cooking), Wikipedia.

Fig 6: Offset smoker.



Source: Marianski *et al.*, 2012; Smoking (Cooking), Wikipedia.

Fig 8: Smoke box.



Source: Marianski *et al.*, 2012; Smoking (Cooking), Wikipedia.

Fig 7: Electrical smoker.



Source: Marianski *et al.*, 2012; Smoking (Cooking), Wikipedia.

Fig 9: Vertical water smoker.

are relatively low cost and desired stable temperature can be achieved easily.

Constraints

Apart from all the specialties and benefits that ethnic smoked foods offer, they have limitations which act as constraints for commercialization (Kadirvel *et al.*, 2021). These include:

- Improper facilities and poor hygienic and quality control by food handler/ producers.
- Improper controlled environment during processing may lead to cross-contamination from adulterants and allergens which in turn render the products unsafe for human consumption.
- Improper maintenance of protocol, lack of standardization of procedures for processing.
- Lack of training given to food handlers and entrepreneur in the sector.
- Lack of marketing strategy and adequate logistics for scaling up to large production.
- Lack of availability and accessibility of proper processing equipment and technical know-how on handling.
- Lack of knowledge on proper packaging materials and transport system.

Strategy for commercialization

Small Scale Enterprises of traditional product with the indigenous technology play a crucial role in generating economy and employment but the main reason for the initial startup failure is inability to overcome constraints (Akaeze and Akaeze, 2017). Some of the crucial points listed below to minimize constraints during commercialization.

- Offering training and consulting services by the agricultural extension agencies.
- Establishing a good infrastructure.
- Facilitating soft loans for small business.
- The capitalist class and the educated youth must come forward with a new vision for the commercialization of the ethnic food products of the region.

CONCLUSION

Smoked food products as a delicacy have always been a food habit of the Himalayan region. The unique method of preparation and the taste and aroma imparted to the products leaves a unique flavor to it. Owing to its preparation method, these products also have numerous nutritional and health benefits. There are numerous types of smoked products prepared from every type of meat in different methods. However despite their popularity in the Himalayan region, the global knowledge and marketing of these items have been lacking throughout the years. Such limitations have been caused due to a lack of commercial promotion from one end. Active promotion and marketing by the regional people can fast track global awareness and thus commercialization of the smoked products. Popularization of the ethnic smoked food products can be done so at a global scale through scientific intervention which can help

to generate employment among the regions and thus the people can be benefited.

ACKNOWLEDGEMENT

Authors would like to acknowledge Director, ICAR Research Complex for NEH Region, Umiam for providing the necessary supports.

Conflict of interest

All authors declare that they have no conflict of interest.

REFERENCES

- Ahlawat, S.S., Sharma, D.P., Khanna, N. and Dabur, R.S. (2012). Development of low fat emulsion based smoked sausages using different humectants. *Asian Journal of Dairy and Foods Research*. 31(4): 306-310.
- Akaeze, N.S. and Akaeze, C. (2017). Exploring the survival strategies for small business ownership in Nigeria. *Australian Journal of Business and Management Research*. 5(7): 35-48.
- Bolaji, O.T., Adeyeye, S.A.O. and Araoye, A. (2022). Effect of smoking and storage conditions on some quality attributes of smoked catfish (*Clarias gariepinus*). *Asian Journal of Dairy and Food Research*. DOI:10.18805/ajdfr.DR-1933.
- Bratzler, L.J., Spooner, M.E., Weatherspoon, J.B. and Maxey, J.A. (1969). Smoke flavor as related to phenol, carbonyl and acid content of bologna. *Journal of Food Science*. 34(2): 146-148.
- Chakravorty, J., Ghosh, S. and Meyer-Rochow, V.B. (2011). Practices of entomophagy and entomotherapy by members of the Nyishi and Galo tribes, two ethnic groups of the state of Arunachal Pradesh (North-East India). *Journal of Ethnobiology and Ethnomedicine*. 7: 1-14.
- Chowdhury, S., Sontakke, P.P., Bhattacharjee, J., Bhattacharjee, D., Debnath, A., Kumar, A. and Datta, J. (2015). An overview of edible insects in Eastern Himalayas: Indigenous traditional food of Tribal's. *Ecology Environment and Conservation*. 21: 1941-1946.
- Das, G. Patra, J.K., Singdevsachan, S.K., Gouda, S. and Shin, H.S. (2016). Diversity of traditional and fermented foods of the Seven Sister states of India and their nutritional and nutraceutical potential: A review. *Frontiers in Life Science*. 9(4): 292-312.
- Dewan, S. (2002). Microbiological evaluation of indigenous fermented milk products of the Sikkim Himalayas. [Ph.D. Thesis]. Food Microbiology Laboratory, Sikkim Government College (North Bengal University), Gangtok, India. p: 162.
- Emine, O. and Bahri, P. (2017). Combined effect of different casing and liquid smoked concentration on the shelf-life of sausages produced from fish (*Capoeta umbla*). *Indian Journal of Animal Research*. 51(5): 956-961. doi: 10. 18805/ijar.v0iOF.6821.
- Fadda, S. and Vignolo, G. (2014). Central and South American Products. *Handbook of Fermented Meat and Poultry*. pp: 355-360.
- Gogoi, B., Dutta, M. and Mondal, P. (2013). Various ethno medicinal plants used in the preparation of Apong, a traditional beverage uses by mising tribe of upper Assam. *Journal of Applied Pharmaceutical Science*. 3(4): 85-88.

- Goulas, A.E. and Kontominas, M.G. (2005). Effect of salting and smoking-method on the keeping quality of chub mackerel (*Scomber japonicus*): Biochemical and sensory attributes. *Food Chemistry*. 93(3): 511-520.
- Hossain, S.A., Pal, P.K., Sarkar, P.K. and Patil, G.R. (1999). Sensory characteristics of dudh churpi in relation to its chemical composition. *European Food Research and Technology*. 208(3): 178-182.
- Jamir, B. and Deb, C.R. (2018). Nutritional assessment and molecular identification of microorganisms from akhuni/axone: A soybean based fermented food of Nagaland, India. *Journal of Advances in Biology*. 11(1): 2170-2179
- Kadirvel, G., Banerjee, B.B., Meitei, S., Doley, S., Sen, A. and Muthukumar, M. (2018). Market potential and opportunities for commercialization of traditional meat products in North East hill region of India. *Veterinary World*. 11(2): 118-124.
- Kadirvel, G., Marak, T.B., Jana, B., Ropmay, M. and Subba, R. (2021). Diversity of traditional food in Northeastern region of India: A review. *Indian Journal of Hill Farming*. 34: 65-74.
- Kardong, D., Deori, K., Sood, K., Yadav, R.N.S., Bora, T.C. and Gogoi, B.K. (2012). Evaluation of nutritional and biochemical aspects of poro apong (*Saimod*)- A home made alcoholic rice beverage of mising tribe of Assam. *Indian Journal of Traditional Knowledge*. 11(3): 499-504.
- Maga, J.A. (1987). The flavor chemistry of wood smoke. *Food Reviews International*. 3(1-2): 139-183.
- Marianski, R.R., Marianski, A. and Marianski, S. (2012). *Meat Smoking and Smokehouse Design*. Bookmagic LLC; 3rd ed. Edition. pp: 338.
- Meitei, L. and Singh, S.B. (2018). Nga-ayaiba: An indigenous fish product of Manipur. *Journal of Humanities and Social Sciences*. 22(8): 56-62.
- Messina, M.C., Ahmad, H.A., Marchello, J.A., Gerba, C.P. and Paquette, M.W. (1988). The effect of liquid smoke on *Listeria monocytogenes*. *Journal of Food Protection*. 51(8): 629-632.
- Mishra, B.K., Das, S., Prajapati, J.B. and Hati, S. (2021). Bio-functional properties and storage study of Chubitchi-A fermented rice beverage of Garo Hills, Meghalaya. *Indian Journal of Traditional Knowledge*. 20(2): 498-511.
- Rai, A.K., Palni, U. and Tamang, J.P. (2009). Traditional knowledge of the Himalayan people on production of indigenous meat products. *Indian Journal of Traditional Knowledge*. 8(1): 104-109.
- Rai, A.K., Tamang, J.P. and Palni, U. (2010). Nutritional value of lesser-known ethnic meat products of the Himalayas. *Journal of Hill Research*. 23(1-2): 22-25.
- Rapsang, G.F., Kumar, R. and Joshi, S.R. (2011). Identification of *Lactobacillus pobuzihii* from tungtap: A traditionally fermented fish food and analysis of its bacteriocinogenic potential. *African Journal of Biotechnology*. 10(57): 12237-12243.
- Riaz, G. and Chopra, R. (2018). A review on phytochemistry and therapeutic uses of (*Hibiscus sabdariffa* L.). *Biomedicine and Pharmacotherapy*. 102(1): 575-586.
- Salloum, H. and Lim, S. (2012). *Arabian nights cookbook: From lamb kebabs to Baba Ghanouj, delicious homestyle Arabian cooking*. Tuttle Publishing.
- Sharma, D.K., Ghosh, K., Raquib, M. and Bhattacharya, M. (2006). Yak products profile: An overview. *Journal of Food Science and Technology*. 43(3): 442-447.
- Shrivastava, K., Greeshma, A. and Srivastava, B. (2015). Improvement in traditional technology of rice and millet based fermented beverages of Arunachal Pradesh, North East, India through scientific approach. In: *Proceedings of the International Conference on Chemical, Environmental and Biological Sciences*, Mumbai, India.
- Sikorski, Z.E. and Kolakowski, E. (2010). Smoking. In: Toldar F, editors. *Handbook of Meat Processing*. Ames: Wiley-Blackwell press; 231-245.
- Singh, A. and Singh, R. (2007). Cultural significance and diversities of ethnic foods of Northeast India. *Indian Journal of Traditional Knowledge*. 06(1): 79-94.
- Steingrimsdóttir, L., Thorkelsson, G. and Eythórsdóttir, E. (2018). Food, nutrition and health in Iceland. In *Nutritional and Health Aspects of Food in Nordic Countries*. 145-177.
- Tamang, B. and Tamang, J.P. (2010). In situ fermentation dynamics during production of gundruk and khalpi, ethnic fermented vegetable products of the Himalayas. *Indian J. Microbiology*. 50: 93-98. doi: 10.1007/s12088-010-0058-1.
- Tamang, J.P. (2010). *Himalayan fermented foods: Microbiology, nutrition and ethnic values*. CRC Press, Taylor and Francis. New York.
- Tamang, J.P. and Thapa, S. (2006). Fermentation dynamics during production of BhaatiJaandr, a traditional fermented rice beverage of the eastern Himalayas. *Food Biotechnology*. 20: 251-261. doi: 10.1080/08905430600904476.
- Thapa, N., Pal, J. and Tamang, J.P. (2004). Microbial diversity in ngari, hentak and tungtap, fermented fish products of North-East India. *World J. Microbiol Biotechnol*. 20: 599-607. doi: 10.1023/B:WIBI.0000043171.91027.7e.
- Thapa, N., Pal, J. and Tamang, J.P. (2006). Phenotypic identification and technological properties of lactic acid bacteria isolated from traditionally processed fish products of the Eastern Himalayas. *International Journal of Food Microbiology*. 107: 33-38. doi: 10.1016/j.ijfoodmicro.2005.08.009.
- Thapa, N., Pal, J. and Tamang, J.P. (2007). Microbiological profile of dried fish products of Assam. *Indian J. Fisheries*. 54: 121-125.
- Tilgner, D.J. (1976). The Phenomenon of Quality in the Smoke Curing Process. In: *Advances in Smoking of Foods*. [Rutkowski A. (editor).] Newyork: Pergamon Press. pp 1629-1638.
- Toth, L. and Potthast, K. (1984). Chemical aspects of the smoking of meat and meat products. In *Advances in Food Research*. 29: 87-158.
- Vaz-Velho, M. (2003). Smoked foods: Production. In: Caballero B, editor. *Encyclopedia of Food Sciences and Nutrition*. Academic Press. 5302-5309.
- Woods, L. (2003). Smoked Foods: Principles. In: *Encyclopedia of Food Sciences and Nutrition*. [Caballero B, (eds).], Academic Press. pp 5296-5301.