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Review Article

Rice-Based Alcoholic Fermented Beverages of North-East India: Insight into Ethnic Preparation, Microbial Intervention, Ethnobotany, and Health Benefits

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Introduction. Alcoholic fermented rice-based beverages (AFRBs) have been used since time immemorial for spiritual connection and cultural rituals in North-East India. AFRBs are also used traditionally in the healthcare system for remedy of tiredness, digestion problems, hypertension, and diabetes. *Problems Statement*. Limited scientific documents are available on AFRBs including starter cake preparation, production of the beverages, microbial intervention, nutritional aspects, and health benefits. *Objectives*. This review has been undertaken to find insight into ethnic preparation, microbial intervention, ethnobotany, and health benefits as well as nutritional aspects of popular AFRBs of North-East India. *Major Findings*. Studies reveal that AFRBs are enriched with medicinal benefits due to the presence of various microflora and medicinal plants. The presence of medicinal plants plays an important role underlying the health benefits of AFRBs. In addition, several functional microorganisms, such as strains of *Lactobacillus* and yeast, enhance the therapeutic potential of the AFRBs. Interestingly, strains of *Pediococcus* and *Lactobacillus* spp. improve bile and gastric juice tolerance, hyperlipidemia, diabetes, obesity, and amylolytic activities and regulate the expression of fatty acid biosynthetic genes. Moreover, strains of *Saccharomyces* decrease the secretion of proinflammatory cytokines and alter the respective mRNA expression. Furthermore, the consumption of AFRBs has no harmful effect among the communities on a regular basis in normal diet. *Conclusion*. A detailed scientific approach is required to maintain the desired product quality of AFRBs for the upliftment of the socioeconomic status of North-East India.

1. Introduction

Fermentation is the oldest preservation technique that enhances the quality of food along with the improvement of flavor and taste. Fermentation is also helpful in the digestion of food because of the breakdown of complex food components into smaller fragments with increasing nutrient quality. Moreover, fermented foods are enriched with various amino acids, peptides, isoflavones, and other small molecules along with yeast or bacterial microorganisms [1–5]. Fermentation is widely used in the Indian subcontinent since the civilization of humans for preservation of foods and sustained nutrition and is used for traditional purposes [6–8]. In ancient times, it was adopted for the preservation of excessive seasonal foods in clay pots which perished easily [9]. These preserved foods are consumed which have pleasant aroma and are nontoxic.

From a nutritional standpoint, it underscores the essential requirement of foods for the regular growth of the biological system. Essential needs include amino acids, fatty acids, vitamins, proteins, and minerals that lead to preventing nutritional deficiencies in the biological process. Moreover, most of the biogenic amines are responsible during fermentation through reductive amination, transamination, decarboxylation, and degradation of precursor amino acids [10]. However, the concentration of alcohol and other desired content varies depending upon the fermented or nonfermented processes. In fermented alcoholic beverages, ethanol is produced through distillation or maceration of raw materials, such as beer, wine, and spirit. However,

consumption of fermented beverages is used as an antidepressant on monoamine oxidase [11]. Whereas, non-fermented beverages are normally alcohol-free beverages, such as energy drinks, dairy beverages, fruit juices, and vegetable juices (soy, rice, and almond). Normally, vegetable-based drinks are water containing beverage prepared from legumes, oil seeds, cereals, and fruits. [10]. However, fermentation is not only about providing the energy for microorganisms but also about transforming food items to consumables with the help of microbial interventions [12]. It was suggested by some anthropologists that stimulation of fermented beverages has encouraged people to settle down in fertile agricultural fields. However, limited scientific information is available on rice-based fermented alcoholic beverages of North-East India, emphasizing traditional preparations and its challenges [13, 14]. Therefore, we specially emphasized on how plants and herbs conjugate with microbes during preparation and the health benefits of fermented beverages of North-East India. This review has been carried out to find a detailed insight into ethnic preparation, microbial intervention, ethnobotany, and health benefits of popular alcoholic fermented rice-based beverages of North-East India.

2. Current Scenario of Rice-Based Alcoholic Fermented Beverages

Fermentation of food products with increasing shelf-life and desired characteristics is the oldest biotechnological method [15]. Among various fermented food products, rice-based beverage is one of the oldest fermented food products in North-East India. During the fermentation process, microbes play an important role which is specific to physiological parameters. In this region, the most common microbial intervention includes lactic acid bacteria, *Saccharomyces*, and *Bacillus* species [16]. Moreover, it is reported in Ramayana that fermented alcoholic beverages have been consumed since pre-Vedic ages as an essential part of human diet [17].

Nowadays, fermented beverages have been consumed as nutritional and therapeutic aspects. Ray et al. reported that the predominant probiotics such as lactic acid-producing bacteria and yeast are biochemically active in the intestine. The probiotics derived from food or beverages are popular because they secrete various beneficial bioactive compounds, have lack of pathogenicity, have more survivability rate in environmental stress, and are regarded as safe [18]. Moreover, launch of various new fermented products ameliorates taste and increases the durability of the shelf-life that motivates towards the consumption of AFRBs among the people who boost the fermented alcoholic beverages' market exponentially. Therefore, it might play a tremendous role in the human healthcare system as well as industrial sectors.

3. Popular Ethnic Alcoholic Fermented Rice-Based Beverages of North-East India

The North-Eastern part of India stands as a rich tapestry of ethnic diversity, with each community boasting its own vibrant cultural heritage. One prevalent practice among these communities revolves around the consumption of rice-based alcoholic fermented beverages. This tradition holds significant in various aspects of socioeconomic, cultural, and religious life, becoming a customary element in ceremonies such as marriages, festivals, births, and even death ceremonies, persisting since time immemorial [16]. However, it is also reported that drinking small quantities of rice beverages has a strong potency to reduce tiredness, headache, digestion problems, blood pressure, and diabetes [13]. Although rice is the main substrate for the fermentation of beverages, the uses of the starter cake or starter culture play a major role during fermentation. There are different indigenous procedures which give the diverse taste of beverages among the respective communities due to the uses of medicinal plants in starter cakes [13]. The uses of medicinal plants or herbs in the preparation of the starter cake possess various healing potencies in curing health problems. The rice-based alcoholic fermented beverages are known in various names in different ethnic communities of North-East India as shown in Figure 1. The names of alcoholic fermented beverages, starter cake and community, and its associated microorganisms are shown in Table 1. The schematic ethnic preparation of some of the major alcoholic fermented beverages which are traditionally used by various ethnic groups of North-East India is shown in Figure 2 and mentioned below in detail [13].

3.1. Ethnic Preparation of Apong. *Apong*, a fermented rice-based alcoholic beverage, is popular among the Mishing tribe in Assam. The Mishing people use *Apong* as an integral part of social, religious, and cultural purposes [45, 46]. *Apong* stands as a symbol of honor, and for the host family, welcoming guests with a glass of this traditional *Apong* is a source of immense pride. It is processed by mixing prepared rice with cake (*E'pob*). The *E'pob* is prepared by mixing leaves of about 26 medicinal plants such as *Adhatoda vasica* (Linn.) Nees, *Asimina obovata* (Willd.) Nash, *Costus speciosus* (J.Koenig) Sm., *Centella asiatica* (Linn.) Urban, *Hydrocotyle sibthorpioides* Lam., *Lygodium japonicum* Thunb., *Plumbago zeylanica* (Linn.) Cav., *Piper longum* Linn., *Piper nigrum* Linn., *Phlogacanthus thyrsiflorus* Nees, *Scoparia dulcis* Linn., and *Swertia chirayita* (Roxb.) Buch.-Ham. ex C.B.Clarke with rice flour. There are two kinds of *Apong* produced by missing communities such as *Nogin apong* and *Po:ro apong* or *Chai mod*. Preparation of the starter cake of *Apong* and its ethnic preparation of *Po:ro apong* and *Nogin apong* are shown in Figures 3(a), 4(a), and 4(b), respectively.

3.1.1. Ethnic Preparation of Po:ro Apong. *Po:ro apong* is also recognized as *Chai mod* for its charcoal-like texture. It emerges not just as a drink but as a symbol of ethnic identity that signifies the essence of tradition and popularity within this distinctive cultural tapestry. *Po:ro apong* is prepared by the blend of meticulously cooked rice (glutinous or sticky variety), entwined with ash derived from burned paddy straw and husk, and *E'pob*. The cooked rice is cooled down on banana leaves, and all the ingredients are mixed with *E'pob* (1 piece per 1 kg). The entire mixture is incubated on the fumigated earthen pot (*Kili'ng*), sealed with dried straw

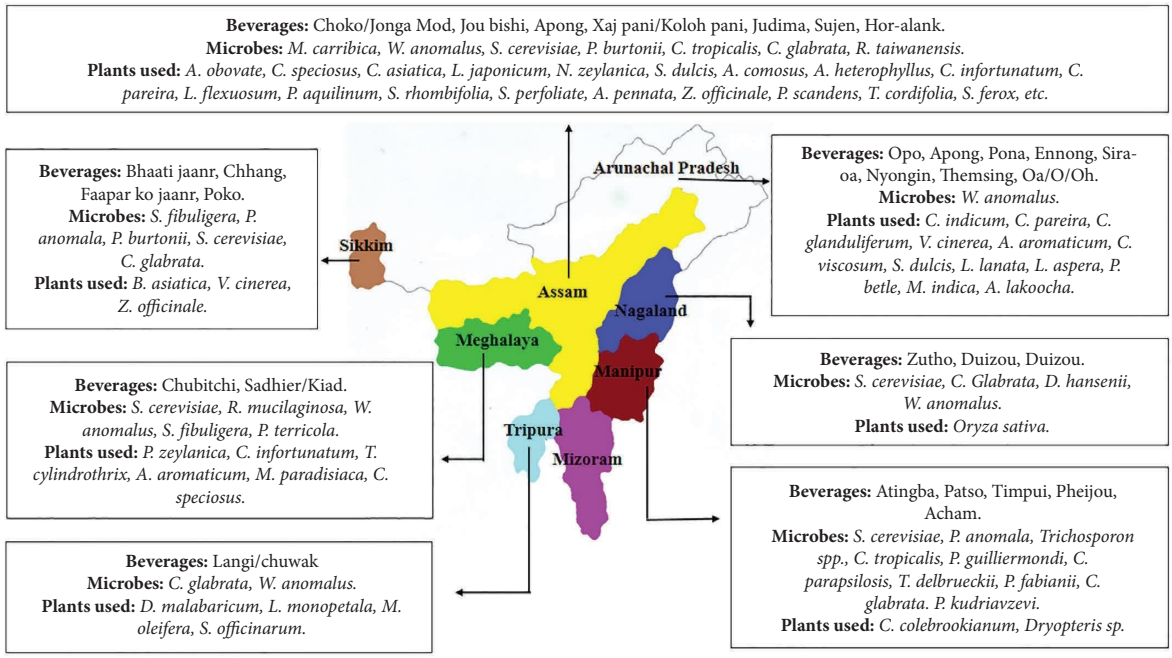


Figure 1: Traditional alcoholic fermented rice-based beverages and microbial association of North-East India.

as well as banana leaves and further incubated for either 12–15 days (winter) or 6–8 days (summer). The beverage is filtered in a cone-sized basket (*Ta:suk*), and the fermented pack (*Amrong*) is poured into the *Ta:suk* from above. After repeating 3-4 times, filtered *Po:ro apong* is obtained and ready to drink and the residual filtrate is used in piggery and fishery farms as a feed [45].

3.1.2. Ethnic Preparation of Nogin Apong. *Nogin apong* is another type of *apong* that is white in colour. It is enjoyed as an energy drink upon returning from work, providing a revitalizing experience. No ritual is considered complete without the offering of *Apong* to the respective deity [45]. *Nogin apong* undergoes the meticulous processing method involving the amalgamation of cooked rice and *E'pob*. The prepared rice is cooled either on a mat or banana leaves. The cooled rice is mixed with *E'pob* (considerable ratio) and incubated in the earthen pot for 5-6 days (summer) or 8–12 days (winter) and sealed with dried straw and leaves of banana for complete fermentation. The product undergoes a dilution process for filtration using a sieve. The product is the attainment of milky white *Nogin apong*, now ready for consumption. The remaining residue is also used as feed of pig and fish. Preparation and extraction of *Po:ro apong* are comparatively laborious than *Nogin apong* [45]. It is believed that drinking of 2-3 (500 mL) glasses of *apong* on a daily basis can prevent the formation of kidney stones and can also be used as an energy booster [45].

3.2. Ethnic Preparation of Atingba or Waiyu. *Atingba* or *Waiyu* possesses a strong characteristic of vodka. It is mainly prepared by the women of Meitei community of the state Manipur, Assam. It is a rice-based alcoholic beverage processed from glutinous rice. The starter cake (*Hamei*) is prepared using rice and blended with the parts of the plants *Albizia myriophylla* Benth., *Clerodendrum colebrookianum* Walp., and *Dryopteris* spp. and kneaded to soft dough with a small quantity of already prepared *Hamei*. From this, small flat round (2–7 cm) *Hamei* is made with a thickness ranging from 0.6 to 1.5 cm. Subsequently, these cakes undergo incubation on dry rice husks, meticulously sealed within banana leaves, and are left within baskets for a duration of 2-3 days. Upon completion of the fermentation process, the cakes undergo a transformative stage, swelling in size. They spread out a distinctive alcoholic aroma and flavor, accompanied by a noticeable shift in color towards yellowish [39, 47]; [38, 48]. During the production of *Atingba,* local rice is cooked with excess water to soften the rice and then cooled by laying over in a bamboo mat over the banana leaves. When the temperature is around 40 degrees, crushed *Hamei* is mixed well with hands (5 cakes per 10 kg of rice) and allowed for the fermentation process by putting inside the large clay pots covered with *Alocasia* sp. for 6-7 days in winter and 3-4 days in summer season. The mixture is submerged in clay pots for 2-3 days. A yellowish product is obtained after filtration, which is called *Atingba* [47]. The detailed starter cake and beverage preparation are shown in Figures 3(b) and 4(c). Moreover, the lactic acid bacteria were isolated from *Hamei* and were identified as *Pediococcus pentosaceus* and *Lactobacillus plantarum* [25]. It is believed that the yellowish product (*Atingba*) regulates the menstrual cycle of women, and it is also used as a medicine for loss of appetite and obesity.

3.3. Ethnic Preparation of Bhaati Jaanr. *Bhaati jaanr,* a traditional rice-based alcoholic beverage, holds cultural significance among the Nepali community in Sikkim, Nepal,

Table 1: Traditional alcoholic fermented rice-based beverages, starter cake, ethnic community, and microbes present in North-East India.

State	Fermented rice beverages	Starter cake	Ethnic community	Microbes found in fermentation	References
Arunachal Pradesh	*Opo/Kala apong*	*Siiyeh*	Adi, Galo, Nishi, Mishmi	*Wickerhamomyces anomalus*	[19, 20]
	Yu	*Old Starter cake*	Idu, Mishmi	Not reported	[21]
	Themsing	*Pham/Phab*	Monpa	Not reported	[20, 22]
	Nyongin/Chhang, arrak, kinnauri	*Opop*	Galo	*Wickerhamomyces anomalus*	[21]
	Sira-oa/Oa/O/Oh	*Paa*	Apatani	*Wickerhamomyces anomalus*	[23]
	Apong	*Ipoh*	Monpa, Apatani, Nishi	*Wickerhamomyces anomalus*	[24–26]
	Pona/Ennog	*Ipoh/Siye*	Monpa, Apatani, Nishi, Adi	*Wickerhamomyces anomalus*	[24–26]
Arunachal Pradesh/Sikkim	*Rakshi*	*Marcha*	Sherdukpen, Monpa, Idu Mishmi	Not reported	[20, 22, 27, 28]
Assam	*Apong*	*Apop pitha*	Mishing	*Amylolytic* microbes, *Rhodotorula taiwanensis*, and *Wickerhamomyces anomalus*	[24, 26, 29]
	Jonga-mod	*Bakhor/ Surachi/Phap*	Rabha	*Meyerozyma caribbica* and *Wickerhamomyces anomalus*	[24, 26, 30]
	Jou bishi	*Emao/Amao/ Angkur*	Bodo	LAB, *Roseburia, Faecalibacterium* sp., *Saccharomyces cerevisiae, Pichia burtonii,* and *Wickerhamomyces anomalus*	[31–34]
	Xaj pani/Koloh pani	*Vekur pitha/Xaj pitha*	Ahom	*Candida tropicalis* and *Candida glabrata*	[19, 24]
	Arak/Hor alank	*Thap*	Karbi	*Saccharomyces cerevisiae, Pichia burtonii,* and *Wickerhamomyces anomalus*	[31, 33–35]
	Sujen	*Perok kushi*	Deori	Not reported	[36]
	Judima	*Humao*	Dimasa Kachari	*Lactobacillus* sp., *Bacillus* sp., *Pediococcus pentosaceus, Micrococcus* sp., *Staphylococcus aureus, Saccharomyces cerevisiae, Debaryomyces hansenii, Rhizopus,* and *Mucor*	[19, 24, 26, 37]
Manipur	*Atingba/Waiyu*	*Hamei*	Meitei/Kabui	*Pediococcus pentosaceus, Saccharomyces cerevisiae, Pichia anomala, Trichosporon* spp., *Candida tropicalis, Pichia guilliermondii, Candida parapsilosis, Torulaspora delbrueckii, Pichia fabianii, Pichia kudriavzevii,* and *Candida glabrata*	[38, 39]
	Patso	*Chamri*	Tangkhul	Not reported	[23]
	Timpui/Pheijou/Zouju	*Khai*	Zeliangrong/Kuki	Not reported	[21]
	Acham	*Chamri*	Tangkhul	Not reported	[23]
Meghalaya	*Chubitchi*	*Wanti*	Garo	*Lactobacillus plantarum* KGL3A, *Lactobacillus fermentum* KGL4, *Saccharomyces cerevisiae* WTS1A, *Saccharomyces cerevisiae, Rothia mucilaginosa, Wickerhamomyces anomalus, Saccharomycopsis fibuligera,* and *Paraburkholderia terricola*	[13]
	Kiad/Sadhier	*Thiat*	Jaintia, Khasi	*Saccharomyces cerevisiae, Rothia mucilaginosa, Wickerhamomyces anomalus, Saccharomycopsis fibuligera,* and *Paraburkholderia terricola*	[13, 40]

Table 1: Continued.

State	Fermented rice beverages	Starter cake	Ethnic community	Microbes found in fermentation	References
Mizoram	*Rakzu/Zupui/Zufang/Tinzu*	*Damdim/ Dawdim*	Mizo tribe	Not reported	[23]
Nagaland	*Zutho/Zhuchu*	*Piazu/Khrei/ Khekhrii*	Angami	*Saccharomyces cerevisiae, Saccharomyces cerevisiae* Naga 97, *Candida glabrata, Wickerhamomyces anomalus,* and *Pichia anomala*	[19, 24, 41]
	Duizou/Jou	*Khekhrii*	Naga	*Saccharomyces cerevisiae, Candida glabrata, Wickerhamomyces anomalus,* and *Pichia anomala*	[19, 24, 38]
Sikkim	*Bhaati jaanr*	*Marcha*	Gorkha, Bhutia, and Lepcha	*Pediococcus acidilactici, Saccharomycopsis fibuligera, Corchorus capsularis, Pichia anomala, Pichia burtonii, Saccharomyces cerevisiae, Saccharomyces bayanus,* and *Candida glabrata*	[38, 42–44]
	Poko	*Manapu*	Gorkha	Not reported	[25]
	Chhang/Chyang/Chee	*Phab*	Gorkha, Bhutia, and Lepcha	Not reported	[21]
	Faapar ko Jaanr/Simal tarul ko jaanr/Makai ko jaanr/Kodo ko jaanr/Jao ko jaanr	*Marcha*	Gorkha, Bhutia, and Lepcha	*Saccharomycopsis fibuligera, Corchorus capsularis, Pichia anomala, Pichia burtonii, Saccharomyces cerevisiae, Saccharomyces bayanus,* and *Candida glabrata*	[21]
Tripura	*Langi/chuwak*	*Chuwan*	Tripuris	*Candida glabrata* and *Wickerhamomyces anomalus*	[1]

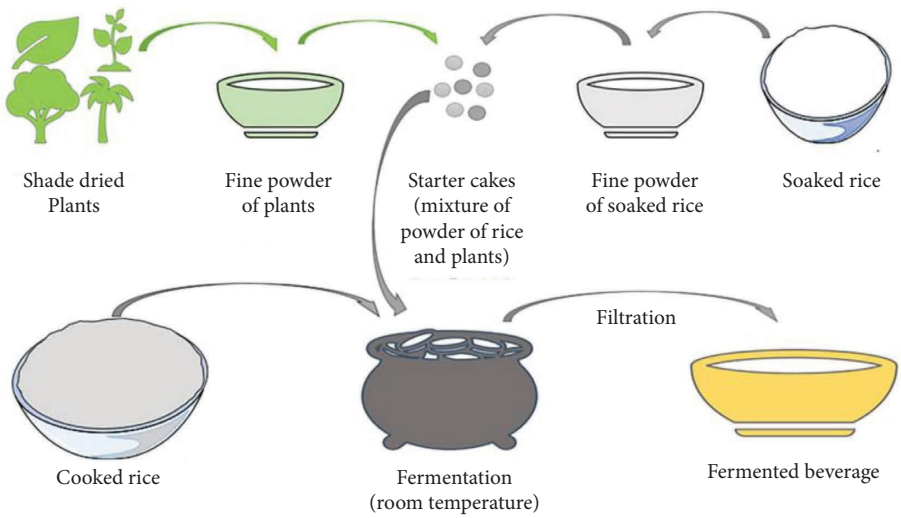
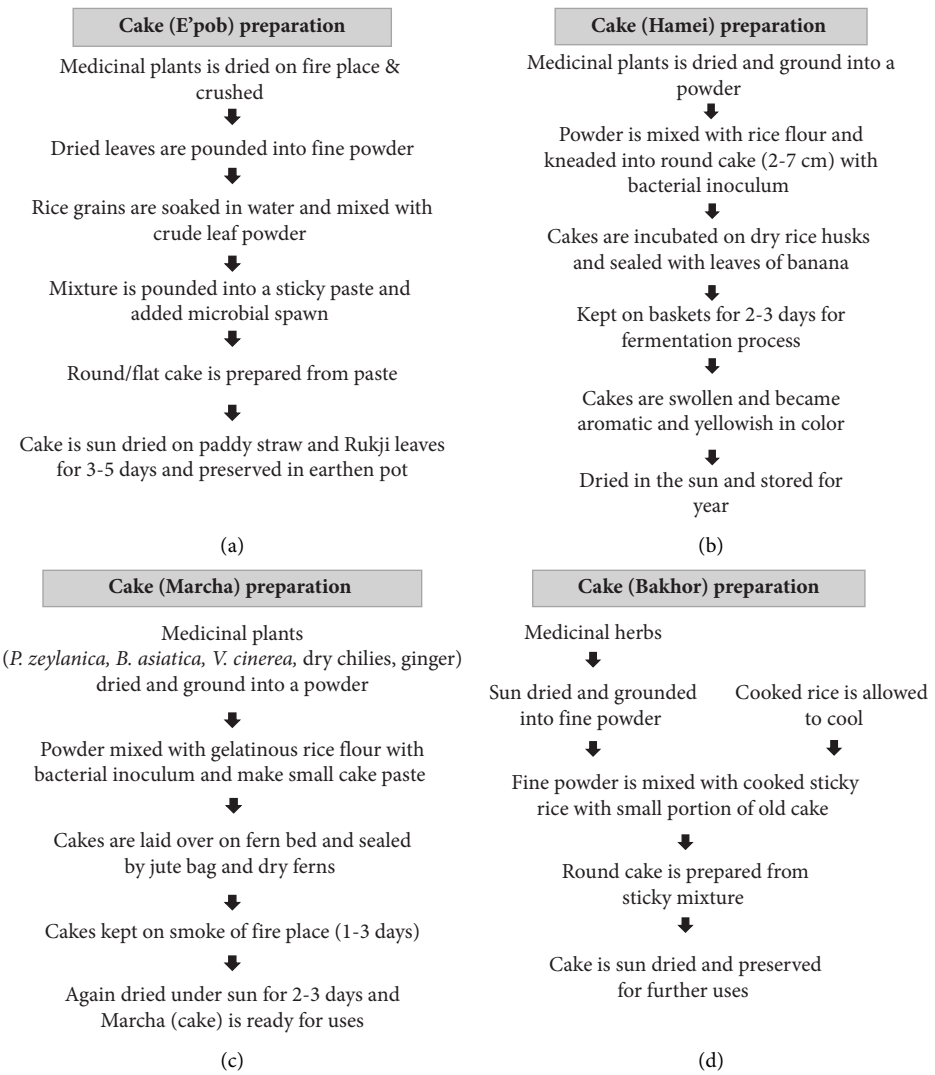


Figure 2: Schematic representation of production of alcoholic fermented rice-based beverages.



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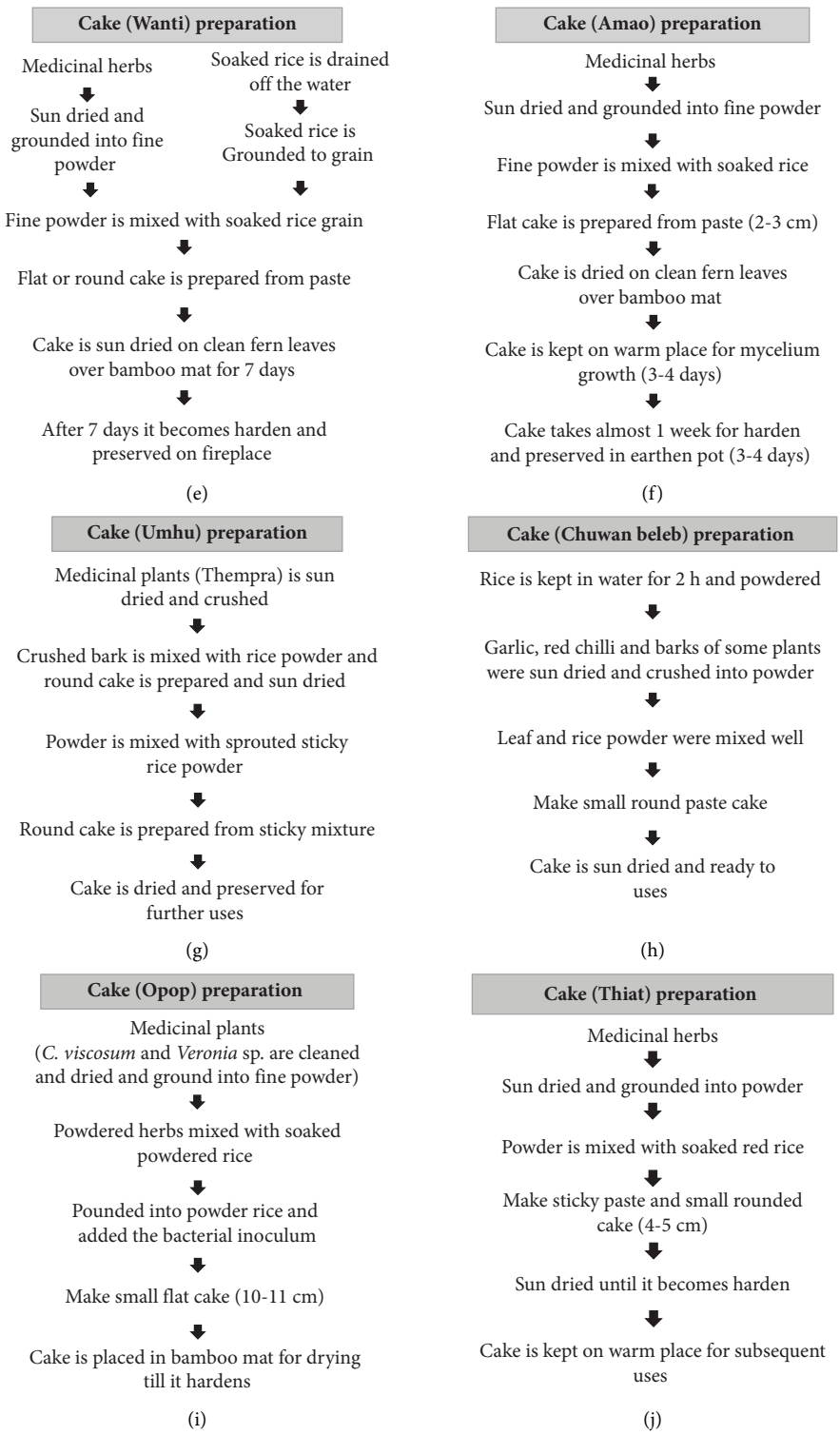

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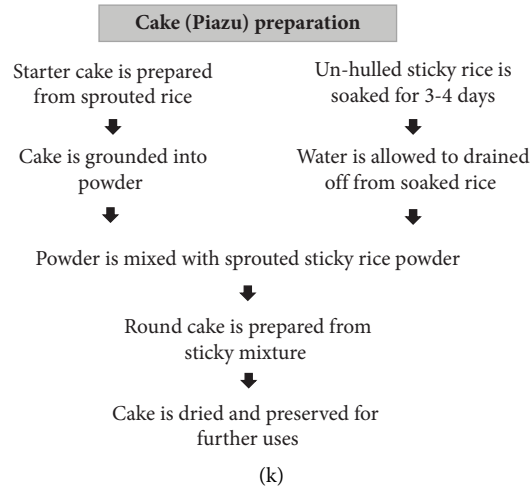

Figure 3: Schematic representation of preparation of the starter cake or starter culture of alcoholic fermented rice-based beverages in North-East India. (a) Cake (*E'pob*) preparation. (b) Cake (*Hamei*) preparation. (c) Cake (*Marcha*) preparation. (d) Cake (*Bakhor*) preparation. (e) Cake (*Wanti*) preparation. (f) Cake (*Amao*) preparation. (g) Cake (*Umhu*) preparation. (h) Cake (*Chuwan beleb*) preparation. (i) Cake (*Opop*) preparation. (j) Cake (*Thiat*) preparation. (k) Cake (*Piazu*) preparation.

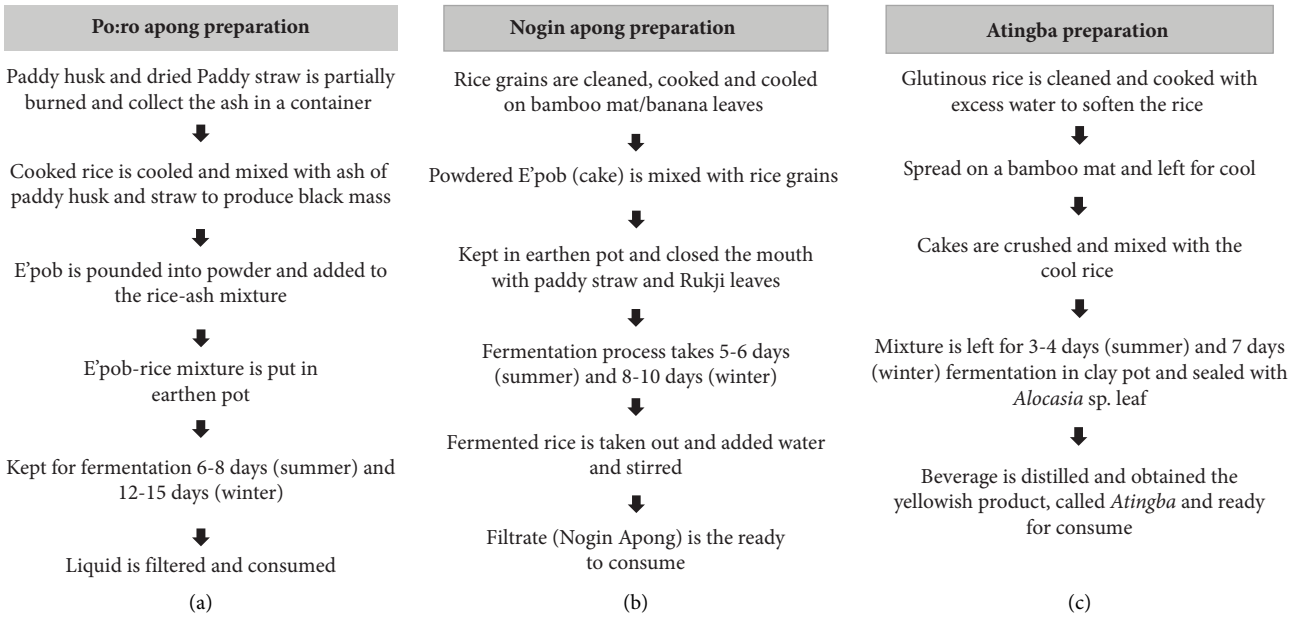

Figure 4: Continued.

Bhaati jaanr preparation

Cooked glutinous rice is laid over mat and allowed to cooled down

⬇

Marcha powder is mixed with cooked rice and incubated in earthen pot for 1-2 days at room temp.

⬇

Mouth is sealed and kept tightly for 2-3 days (summer) and 7-8 days (winter)

⬇

Fermented Bhaati jaanr is stirred with stirrer and consumed directly

⬇

Stored for week or more until yellowish white color is obtained, called *Nigaar* (addition of water)

(d)

Choko or Jonga-mod preparation

Sticky rice is cleaned and washed with water

⬇

Cooked rice is lay over mat and allowed to cool

⬇

Powdered cake is mixed with cooked rice

⬇

Mixture is kept into earthen pot & sealed with banana leaves (warmed on fire)

⬇

Incubated for up to 4-5 days in dark

⬇

Juice is distilled from the mixture using earthen pot, and ready to consume

(e)

Chubitchi preparation

Clean the rice & washed with water

⬇

Rice is cooked and lay over mat

⬇

Powdered cake is mixed with cooked rice

⬇

Mixture is kept into earthen pot and sealed with banana leaves

⬇

Incubated for up-to 1 week (summer) and 1 month (winter)

⬇

Juice, *Chubitchi* is harvested from the mixture

(f)

Jou bishi preparation

Rice is cleaned and washed with water

⬇

Rice is soaked from water

⬇

Powdered cake 1-2 piece is mixed with rice (1 kg)

⬇

Mixture is covered with banana leaves and kept for 2-3 days

⬇

Mixture is transferred to earthen pot (Maldang) and sealed with banana leaves

⬇

Incubated for 5-6 days of fermentation

⬇

Yellowish juice, *Jou bishi* is harvested from the *maldang*

(g)

Judima preparation

Glutinous rice is cooked and cooled on banana leaves

⬇

Cake powder is mixed gelatinous cooked rice

⬇

The mixture is kept on large container and mouth is sealed with jute fibers

⬇

Incubated for 5-6 days

⬇

The formation of yellowish juice is pure form of *Judima*

⬇

Liquid is filtered and consumed

(h)

Langi preparation

Cooked rice is lay over bamboo mat for cooling

⬇

Cake powder is mixed up with cooked rice well (50 g:1 kg)

⬇

The mixture is incubated inside bucket and covered with banana leaves for 3 days

⬇

Water is added after incubation and yellowish liquid is filtered out and consumed

⬇

Fermented liquid is heated and passed through cold water and distilled *Langi* is obtained

(i)

Figure 4: Continued.

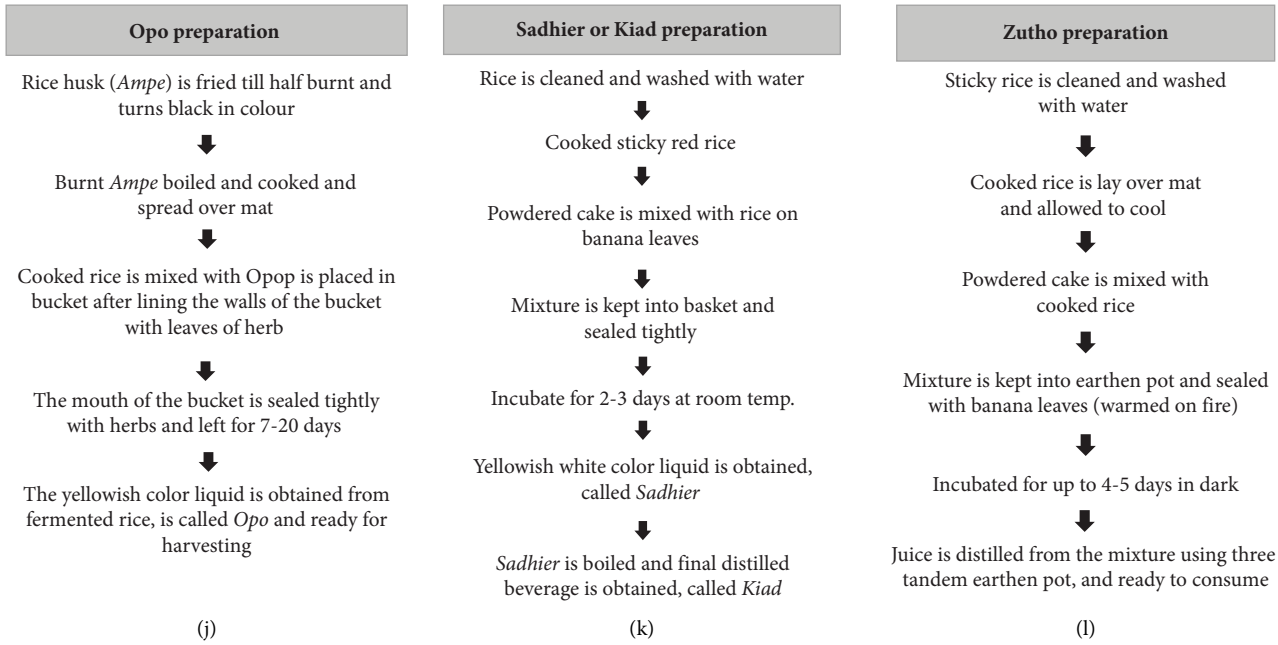

Figure 4: Schematic representation of preparation of alcoholic fermented rice-based beverages in North-East India. (a) *Po:ro apong* preparation. (b) *Nogin apong* preparation. (c) *Atingba* preparation. (d) *Bhaati jaanr* preparation. (e) *Choko* or *Jonga-mod* preparation. (f) *Chubitchi* preparation. (g) *Jou bishi* preparation. (h) *Judima* preparation. (i) *Langi* preparation. (j) *Opo* preparation. (k) *Sadhier* or *Kiad* preparation. (l) *Zutho* preparation.

and Bhutan. This high-energy beverage is meticulously crafted from glutinous rice, complemented by the blending of a starter cake and *marcha* [44, 49]. *Marcha* is prepared by soaked glutinous rice and leaves of *Buddleja asiatica* Kurz, roots of *Plumbago zeylanica* (Linn.) Cav., red dry chilies, flowers of *Vernonia cinerea* Sahadevi, *Zingiber officinale* Roscoe, and a small amount of old *marcha*. The complete blend is ground, a paste was made by adding adequate amount of water, and small-sized flat cakes were made. The prepared cake is laid over on a bed of ferns of *Gardenia erubescens* Wall. and sealed with jute bags and dry ferns. It is strategically placed on top of the kitchen, allowing the permeation of smoke for 1–3 days. Subsequently, it undergoes a sun-drying process for additional 2-3 days, culminating in the readiness of *marcha* for utilization. In the preparation of *Bhaati jaanr*, the cooked glutinous rice is meticulously laid out over a mat, facilitating a gradual cooling at approximately 40°C. *Marcha* (2 gm) is blended with cooked rice (1 kg) and incubated in an earthen pot or a vessel (1-2 days) at room temperature. After saccharification, the mouth is sealed and kept it tightly for 7-8 days in winter and 2-3 days in summer. Following fermentation, *Bhaati jaanr* undergoes a careful stirring process with a wooden or bamboo ladle, ready for direct consumption. The ethnic preparation of *Bhaati jaanr* and starter cake is shown in Figures 3(c) and 4(d), respectively. Nevertheless, *Bhaati jaanr* exhibits an impressive shelf-life, allowing for storage for a week or more. During this period, it attains a distinct yellowish-white color and is alternatively referred to as "*Nigaar*." This variant is typically consumed by diluting it with water before consumption. Furthermore, microbial strains such as strains of *Lactobacillus bifermentans* (LAB), yeast, and molds are isolated from *Bhaati jaanr* [44]. Due to its high caloric content, *Bhaati jaanr* is specifically utilized for postnatal women and elderly individuals grappling with health issues, serving as a nutritional powerhouse to fortify and strengthen the body. In addition, it boasts medicinal properties attributed to the incorporation of medicinal herbs within the rice brew, enhancing its health-promoting attributes.

3.4. Ethnic Preparation of Choko or Jonga-Mod. *Choko* is an alcoholic rice beverage distinctive to the Rabha tribe of Assam. The preparation of *Choko* involves the meticulous blending of freshly prepared rice (2 kg) with cakes (Choko; 2-3 pieces). The fresh *Choko* (~10 gm) is processed by blending flour with various parts of ten varieties of medicinal plants, such as *Ananas comosus* (Linn.) Merr., *Artocarpus heterophyllus* Lam., *Asclepias gigantea* Lam., *Capsicum frutescens* Linn., *Clerodendrum infortunatum* Linn., *Plumbago indica* (Linn.) Kuntze, *Saccharum officinarum* Linn., *Scoparia dulcis* Linn., and a small amount of old *Choko*. The cooked rice is allowed to cool down on mat. Following the cool down process, the rice and *Choko* are blended and placed in a handmade cylindrical bamboo sieve (*Janthi*) which helps in harvesting the *Choko* or *Jonga-mod* and is placed in *Jonga* (earthen pot). The pot's opening is securely sealed with banana leaves and gently warmed by fire. The blending is left to incubate for 4-5 days in darkness, with the additional safeguard of charcoal to ward off any perceived evil forces. Following the harvesting of *Choko* or *Jonga-mod*, a significant amount of water is incorporated into the mixture. Following 4-5 days of fermentation, *Choko* or *Jonga-mod* is preserved and distilled using three tandem earthen pots (*Hadi/Laduki*). The entire apparatus is

meticulously constructed using jute fibers and mud at the junctions, demonstrating a resourceful and locally sourced approach in its assembly. The distilled drink is called "*Fotika*." The detailed preparation of beverages and cakes is shown in Figures 3(d) and 4(e), respectively. The Rabha tribe firmly believes that *Jonga-mod* possesses numerous medicinal and nutritional properties. It is thought to enhance sleep, alleviate headaches and body aches, aid in the recovery of psychiatric patients, and offer remedies for conditions such as diarrhea and other urinary problems. It is also used to enhance the strength of the body and curing of swollen legs in cattle [30].

3.5. Ethnic Preparation of Chubitchi. *Chubitchi,* a traditional rice-based beverage, holds significance among the Garo tribe of Meghalaya, serving as a staple daily drink and playing a crucial role in religious worship and other ritual festivals. *Chubitchi* is processed by blending viscous rice (*Menil*) with cake (*Wanti*) (4000–5000 : 10). Initially, *Menil* is soaked and subjected to the cooking process. Once cooked, *Menil* is carefully laid out on a clean mat to cool down. The prepared mixture is placed in an earthen pot, utilizing a bamboo sieve for the containment. In the final step, the pot is securely sealed with banana leaves and a clean cloth and then incubated for approximately one week during the summer season and around a month in the winter season. This process occurs at room temperature, as depicted in Figure 4(f), [50]. The *Wanti* is processed by mixing rice flour, chilies, a little amount of old *Wanti*, and some medicinal plants such as *Plumbago zeylanica* (Linn.) Cav., *Chaenostoma cordatum* (Thunb.) Benth., *Cyperus clarkei* T. Cooke, and *Clerodendrum infortunatum* Linn. The prepared small flattened cake is sun-dried on a traditional bamboo bucket and covered with clean straw for at least one week and preserved for further uses and depicted in Figure 3(e). The yeasts, such as *Saccharomyces cerevisiae, Wickerhamomyces anomalus,* and *Rothia mucilaginosa*, are responsible for the fermentation process. The Garo tribe consumes this beverage to alleviate the pain in muscle fibers after a day's fieldwork, finding relief in its consumption. Traditionally, it is believed that the consumption of this beverage offers relief from various ailments, including gastrointestinal problems, stomach cramps, menstrual cramps among women, and joint pain, and serves as an antiageing agent. Furthermore, there are claims that the usage of this beverage can potentially cure various illnesses. However, it is important to note that as of now, there is no scientific record or evidence to substantiate these claims [51]; [13].

3.6. Ethnic Preparation of Jou Bishi. *Jou bishi* is a fermented alcoholic beverage prepared by the Bodo tribe from rice in the Bodoland region of Assam. *Jou* is prepared by using starter cakes (Amao/*Angkur*) using different parts of medicinal herbs such *Clerodendrum infortunatum* Linn., *Oryza sativa* Linn., *Scoparia dulcis* Linn., and *Xanthium strumarium* J. Koenig [32]. The various parts of plants are sun-dried and ground into fine powder and added with soaked rice *Mairong* (*Oryza sativa* Linn.) with old *Amao* as inoculums. *Amao,* a flat cake (round: 2-3 cm and thickness: 1 cm), is prepared from paste mixture. *Amao* is dried on clean fern leaves (*Dingkia* leaves) over the round bamboo mat (*Songrai*). Following 3-4 days, the cake is kept in a warm place for the growth of mycelium. It takes almost one week until the hardening of the *Amao* and is preserved on a cotton cloth in a small earthen pot (*Dwihu*). *Jou bishi* is prepared by the blending of *Mairong* with *Amao* (1-2 pieces per 1 kg). The blending (*Jumai*) is covered by banana leaves (*Talir bilai*) and left for 2-3 days without disturbance. *Jumai* is transferred to a big earthen pot (*Maldang*) with a conical bamboo sieve (*Janta*), and the mouth is sealed with leaves of banana and cloth followed by incubation of 5-6 days. A yellowish juice is harvested from *Maldang* called *Jou bishi.* Following harvest, *Jou bishi* is again kept for 3-4 days. The distilled form of *Jou bishi* is called *Jou gwran* and diluted with a significant amount of water and is ready to drink. *Jou gwran* is highly alcoholic when compared to *Jou bishi.* The schematic flowcharts are shown in Figures 3(f) and 4(g). It is believed to cure various diseases, such as jaundice, diarrhea, cholera, urinary disorder, and gastrointestinal disorder. It keeps the body relaxed and healthy when consumed in adequate quantity. No scientific report has been found regarding the health benefits of *Jou bishi*. Moreover, *Jou bishi* is also known as a source of livelihood earnings in the rural part of the Bodo land region.

3.7. Ethnic Preparation of Judima. *Judima* is the traditional rice-based alcoholic beverage processed by the Dimasa Kachari tribe of Assam and Nagaland. The cake (*Humao* or *Umhu*) is prepared by adding the medicinal bark of *Thempra* (*Acacia pennata* (Linn.) Willd.) plant and other plants such as *Hedyotis diffusa* Willd. and *Solanum ferox* Linn. with a local variety of rice. Sun-dried *Thempra* is crushed and blended with rice powder to make into small size (2-3 cm), known as *Umhu* or *Humao*. Following that, *Umhu* or *Humao* undergoes sun drying until it achieves the desired hardness for use. For preparing alcoholic rice beverage *Judima*, a local variety of glutinous rice is prepared and laid over a banana leaf to be allowed to cool down. Following, crushed *Umhu* or *Humao* is blended with the previously cooked rice. This mixture is further unloaded into a large container, and the mouth is sealed with jute fibers. Following fermentation (5-6 days), a slightly yellowish juice texture is obtained as a pure form of *Judima.* The detailed procedure of preparations is depicted in Figures 3(g) and 4(h). This liquid is filtered and consumed directly. Sometimes, this is further diluted with a significant amount of water and left for fermentation [19]. This beverage, rich in nutrients, is a daily staple for locals who consume it to alleviate body aches incurred from working in the fields. It is known to give good sound sleep and facilitate good digestion [19].

3.8. Ethnic Preparation of Langi or Chuwak. The Tripuri ethnic group in Tripura prepares *Langi/Chuwak,* which is the distilled form of rice beverage. The undistilled version of this rice beverage is known as *Gora Bwtwk.* The starter cake

(*Chuwan beleb*) is prepared by grounding rice (*Atop mairom*) with various leaves such as *Allium sativum* Linn., *Dysoxylum malabaricum* Bedd. ex C. DC., *Litsea monopetala* (Roxb. ex Baker) Pers. Khuwalu, *Moringa oleifera* Lam., and *Saccharum officinarum* Linn. To prepare *Chuwan beleb*, the process commences by soaking rice in water for 2 h. The soaked rice is then powdered along with raw materials, shaped into small flat cakes (50–100 g), sun-dried, and preserved for future use. In the preparation of *Gora bwtwk*, precooked rice is spread out over a bamboo mat or banana leaves, allowing it to cool for a duration of 2 h. Following the cool down, an adequate quantity of *Chuwan beleb* is added and mixed up with cooked rice (50 : 1000). The mixture of rice and starter is kept inside a large bucket, sealed with banana leaves, and placed on top of it to allow minimum escaping of air. The cooled rice is left for a period of 3 days, during which the container's opening is securely sealed with cloth. Following the fermentation process, water is added and again kept for 2 days. The yellowish substance is filtered out and drunk as undistilled rice beverage. Following the distillation process, *Gora bwtwk* is heated until vapor gets accumulated in another bucket. The vapors are passed through a *Batisabasa* in another cold-water-containing bucket where distillation takes place. The distilled liquid obtained from the process is called *Langi/Chuwak*, and it is consumed directly [49]. The detailed flowchart of preparations of *Langi* and cake is depicted in Figures 3(h) and 4(i). The plants that are used in the starter cake are known to have many medicinal benefits, such as preventing degenerative diseases and skin diseases, treating common cold and jaundice and nervous diseases.

3.9. Ethnic Preparation of Opo. *Opo* is a fermented rice-based alcoholic beverage processed by Adi-Galos tribes in the state of Arunachal Pradesh. *Opo* is prepared by using starter culture (*Siiyeh* or *Opop*). *Opop* is prepared by using medicinal plants, such as *Clerodendrum viscosum* Vent., nom. superfl. Bhati Gach, *Vernonia* sp., *Clerodendrum indicum* Linn., and *Cissampelos pareira* Linn. These plants are cleaned and dried properly before grinding into a fine powder. These powdered herbs are blended with rice, soaked overnight, and pounded into powder. *Opo*, previously prepared, is introduced as an inoculum and shaped into flat cakes measuring 10-11 cm in diameter. This *Opop* is then placed in the bamboo mats for drying till it hardens. During the preparation of *Opo*, the rice husk (*Ampe*) is fried till it is half burnt and turns into black in colour. The burnt *Ampe* is then boiled, cooked properly, and spread over mat (*Peche*). It is blended with *Opop* (~0.01 : 1 kg). This blended substance is then placed in a large bucket after lining the walls of the bucket with leaves of herb *(Oko)* (Zingiberaceae family). Following secure placing the mixture, the mouth is sealed with *Oko* leaves and is left untouched for a week. After a week, the mixture is again mixed up properly and left for a longer duration. The fermented rice beverage *Opo* becomes yellowish in colour after twenty days of fermentation and is ready for harvesting. To harvest *Opo*, the fermented mass is filtered through *Perpur* (funnel), with hot water being passed slowly to extract the *Opo*. The detailed flowchart of preparations of beverage and cake is depicted in Figures 3(i) and 4(j). The concentration of the final product depends upon the amount of poured water [41]. The inclusion of blended medicinal plants results in several medicinal properties which is believed to be the remedies for urinary problems, diarrhea, inflammation, headache, insomnia, and body ache. Moreover, it has the ability to gut-brain connection and develop a positive vibe. It is believed that it enhances the immune system, maintains cholesterol borderlines, and prevents other intestinal diseases.

3.10. Ethnic Preparation of Sadhier or Kiad. *Sadhier* or *Kiad* is a rice-based beverage that is traditionally processed by Pnar tribe in the hills of Jaintia community in Meghalaya. It is prepared by blending the starter cake (*Thiat*) with brewed rice (*Kho-so*). *Thiat* is prepared by the blending of sun-dried leaves of *Amomum aromaticum* Roxb., *Musa paradisiaca* Linn., and *Costus speciosus* (J.Koenig) C.D. Specht with grinded powder of *Oryza sativa* (red rice) gives sticky paste and small-rounded cake (4-5 cm). The cake is sun-dried until it becomes hardened for further uses. For the preparation of *Sadhier* or *Kiad,* the cooked rice is taken out and allowed to cool over the banana leaves and *Thiat* (1-2 pieces) is mixed up with cooled rice. The mixed rice is kept into the cone-sized basket (*Shang*) and kept it for the fermentation (2-3 days) process. The detailed flowchart of preparations of beverage and cake is depicted in Figures 3(j) and 4(k). The fermented rice is distilled in a set apparatus (*Shet-Kiad*) and extracted out the distilled beverage (*Kiad*). *Sadhier* is known for curing urinary problems and dysentery. It becomes a health tonic when consumed in small quantity on a daily basis. However, excess consumption may lead to intoxication. Till date, no scientific intervention has been carried out on the nutritional and medicinal efficacies of *Sadhier* [13]. Moreover, the production of *Sadhier* is a good resource of revenue for the livelihood of native people [40].

3.11. Ethnic Preparation of Zutho or Zhuchu. *Zutho* or *Zhuchu* is an indigenous rice beverage hailing from Nagaland, processed by *Angamis* tribe. *Zutho* is prepared by using unhulled rice (*Oryza sativa* Linn.) and starter cake (*Piazu/Khrei/Khekhrii*). The starter cake, *Piazu*, is processed from sprouted rice. The unhulled rice is soaked with water (3-4 days) and drained out the water. It is left for 1 week or more until it germinates. Following this, the sprouted rice grains are blended into dusty rice mechanically. The *Zutho* is prepared with blending of boiled rice and cooked properly allowed to cool down over a bamboo mat. Following the cool down, ~10 g of *Piazu* per 1 kg of rice is mixed well and then kept in a large container for the fermentation process for about 4–7 days. After the stipulated time, the required amount of water is added to *Zutho*, filtered, and served directly [41]. The detailed flowchart of preparations of beverage and cake is depicted in Figures 3(k) and 4(l). During the fermentation process, *Saccharomyces cerevisiae* Naga97 strain is responsible for the production of ethanol fermentation [41]. *Zutho* is also believed to reduce fever and blood pressure, help in digestion, and is used as energy

booster. Moreover, *Zutho* is traditionally used as a staple beverage, and it is consumed by young and adult people in festive seasons, such as wedding feasts, ceremonies of birth, and naming of newborn babies, and cremation.

4. Microbial Intervention during Fermentation and Its Health Benefits

Ethnic rice beverages boast rich composition of amino acids, carbohydrates, alcoholic sugars, and minerals, contributing to the modulation of the microbial gut ecosystem. The consumption of rice beverages not only provides these nutritional elements but also promotes the colonization of diverse probiotics and microflora, contributing to a more diverse gut environment. During the fermentation of rice beverages, there are some microorganisms responsible for the production of alcoholic beverages such as *Pediococcus acidilactici* strains, *Lactobacillus* strains, *Roseburia* spp., *Faecalibacterium* sp., *Pediococcus pentosaceus*, *Pichia anomala*, and *Saccharomyces* strains which work as probiotics and enhance the health against pathogens. Some microorganisms, involved during the fermentation process, exhibit a beneficial role against metabolic disorders. It is reported that rice beverages (*Jou bishi*) and *Lactic acid bacteria* (LAB) are mostly predominant in fermented rice beverages, and some probiotics are also present that enhance the nutritional utilities [52]. Studies have showed that there is no significant difference observed between the groups that consume the beverage and those that do not within the ethnic communities.

The body mass index and other biochemical parameters were shown in a normal range after long-term consumption [52]. Interestingly, no alcohol-induced obesity was observed despite having long-term consumption. However, the varietal and diversification of microflora were distinctively affected in the gut microbial ecosystem in ethnic community.

The biomarker study showed that *Roseburia* and *Faecalibacterium* genera normally populated and butyric acid was overexpressed in rice beverage nonconsuming guts as compared to consuming guts. It may be due to the conversion of saccharides into short-chain fatty acids which is a good sign for health. Moreover, it was shown that fermented rice beverage consumption lowers the population of bacterial community [52]. *Bhaati jaanr* is one of the fermented rice beverages where novel probiotics were isolated and it possesses a therapeutical role as a bioprotectant. The strain, *Pediococcus acidilactici*, is isolated from *Bhaati jaanr*, and it has the potential role against bile and gastric stress, hydrophobicity, and attachment of colon cells. Moreover, it is susceptible to common antibiotics and inhibition against species of *Enterococcus, Listeria*, *Staphylococcus*, and *Salmonella*. It also showed an antiproliferative role against colon cancer cells due to the high production of butyric acid with short-chain fatty acids [53]. *Pediococcus acidilactici* is a highly promising probiotic that is present in a very harsh gastric and duodenum environment. *Pediococcus acidilactici* UL5 strain has the potential to produce antilisterial bacteriocin pediocin, PA-1. It immobilizes *Listeria monocytogenes* in human intestinal microbiota [54]. Moreover, *Pediococcus acidilactici* FZU106 strain improves the hyperlipidemia-induced lipid metabolism syndrome with the modulation of gut microbiota in hyperlipidemic rats [55], and *Pediococcus acidilactici* CECT9879 strain increases metabolic disorders, including type 2 diabetes and obesity. It reduces fat and glucose accumulation and high glucose-treated (10 mM) *Caenorhabditis elegans*. Moreover, it reduces the reactive oxygen species up to 20% against high glucose exposure and mediates the insulin/IGF-1 signaling pathway. Pediococcus acidilactici CECT9879 caused the reversion of the nuclear localization of daf-16 and overexpression of ins-6 and daf-16 mediators. Furthermore, Pediococcus acidilactici CECT9879also increased the gene expression for mitochondrial and peroxisomal fatty acid degradation and downregulated the gene expression for lipid biosynthesis [56]. Interestingly, supplementation of *Pediococcus acidilactici* pA1c showed antidiabetic property by improvising high-fat-diet-induced type 2 diabetes-derived insulin resistance and preventing from increasing the body weight in mice [57].

In addition to that, *Po:ro apong* contains 7.52–18.5% alcohol contents in which the upper range is relatively higher and lower range is variable depending on the dilution of the product as that of studied fermented rice beverages. Studies showed that amylase enzyme is present in the final liquid product which supports the presence of amylolytic microbes in the fermented product. However, endurance of production of amylase in the product is not clear [58]. Moreover, the microbial load is reduced as compared to starter cakes and ripe mash in the final product of fermentation which may be due to an increase in the concentration of alcohol [59]. Studies reveal that molds, yeast, and bacteria were initially isolated from starter cakes, and among them, only two microbial populations were found in the end product, i.e., yeast and amylolytic bacteria [60]. The excessive amount of amyl alcohol in fermentation may lead to unbearable smell in the final product. Therefore, a proper identification of microbes is required to overcome these harsh conditions [61]. *Pediococcus pentosaceus* and *Pichia anomala* were isolated from *Atingba*, a fermented rice-based beverage from Manipur. The uses of these strains in fermentation improve the quality of beverages in biochemical and microbiological aspects.

Moreover, three-month beverage can inhibit the lipid peroxidation process and enhance the stability of shelf-life of the beverages [62]. A diverse microbial population was found in Judima and its starter cake (Humao) including bacterial strains *Lactobacillus brevis*, *Pediococcus pentosaceus*, *Bacillus licheniformis*, *Leuconostoc mesenteroides*, *Lactococcus lactis*, *Bacillus cereus*, *Bacillus firmus*, *Bacillus subtilis*, *Bacillus stearothermophilus*, *Bacillus circulans*, *Bacillus pumilus*, *Bacillus sphaericus*, *Bacillus polymyxa*, *Bacillus laterosporus*, *Micrococcus* spp., and *Staphylococcus aureus*, and yeasts, such as *Debaryomyces hansenii* and *Saccharomyces cerevisiae* and moulds such as *Rhizopus* and *Mucor*. Moreover, the content of minerals is found to be higher in *Judima* [37]. *Zutho* is another fermented beverage of Nagaland containing 5% ethanol (v/v). Moreover, gas chromatography revealed that volatile esters and alcohol such as 3-methyl butanol and ethyl acetate were detected in it. It has a taste of sour and fruity

aroma in nature. However, *Saccharomyces cerevisiae* is responsible for the fermentation process, and a *Saccharomyces cerevisiae* Naga97 strain was isolated from *Zutho*, prepared by *Angamis* tribe [41]. *Lactobacillus* strains, such as *Lactobacillus plantarum* KGL3A (MG722814) and *Lactobacillus fermentum* KGL4 (MF951099), and *Saccharomyces* strains, such as *Saccharomyces cerevisiae* WTS1A (MG183699), were isolated from *Chubitchi*, a fermented beverage of Meghalaya. *Chubitchi* has a good antihypertension property, i.e., the ACE is inhibited up to 68.04–86.87%. Moreover, it also possesses antioxidant and antimicrobial properties [63]. *Lactobacillus* strains also play an important role in many physiological conditions. For example, *Lactobacillus plantarum* Bom 816 and *Lactobacillus pentosus* N3 strains possess significant amylolytic activity which is involved in lactic acid fermentation [64]. Moreover, *Lactobacillus plantarum* strain L7 isolated from "*Bhaati jaanr*" possesses satisfactory probiotic activity, and it shows bile acid resistance tolerance, antibiotic susceptibility, antimicrobial activities, hydrophobicity in the cell surface, and autoaggregation [65]. However, some *Lactobacillus* spp., such as *Lactobacillus helveticus*, *Lactobacillus delbrueckii, Lactobacillus casei*, and *Lactobacillus bulgaricus*, show high bile tolerance (0.2%), gastric juice tolerance, antibiotic resistance, and cell surface hydrophobicity [66]. *Saccharomyces* strain 28-7 (SC28-7) is also exhibiting probiotic activity in the mice model in which dextran sodium sulfate (DSS) was induced. The supplementation of SC28-7 significantly decreased the secretion of proinflammatory cytokines and altered the mRNA expression of inflammatory cytokine, and this supports intestinal inflammation in colon [67]. *Roseburia* spp., i.e., *Roseburia intestinalis, Roseburia hominis, Roseburia faecis, Roseburia inulinivorans*, and *Roseburia cecicola*, enhance the proliferation and metabolic activities (bowel syndrome, obesity, type 2 diabetes, and allergies). They produce butyrate that maintains immunity and anti-inflammatory activities and also acts as a biomarker in symptomatic diseases [68]. Due to the presence of probiotics in fermented rice beverages, it is highly recommendable to consume which enhances the health in many pathophysiological conditions. The detailed health benefits of alcoholic fermented beverages of North-East India are shown in Table 2. However, lack of inadequate and validatory scientific reports may stand as hinderance to common society.

5. Medicinal Values of the Ethnomedicinal Plants Used in Starter Cakes or Starter Culture

People have relied on traditional medicines since time immemorial for primary defense before the discovery of pharmaceutical medicines. The traditional practitioner values the plants from sprit of knowledge as food, healthcare, and other remedies [69]. According to the World Health Organization, 80% of less developed countries depend on traditional medicines and use for preliminary treatment [69, 70]. Globally, more than 2000 ethnic communities have been practicing traditional medicines [71]. In the Indian scenario, more than 200 ethnic communities have been living in North-East India [72]. They have owned their traditional health care system from surrounding plants and herbs. These plants are not only used in medication but also used in fermentation during the preparation of traditional alcoholic beverages among the tribal communities. Ethnobotany of these plants has huge potential in traditional medicines as well as modern medicines. Some of the medicinally important plant plants which are used during the starter cake preparation, namely, *Clerodendrum indicum* Linn., *Clerodendrum infortunatum* Linn., *Clerodendrum viscosum* Vent., *Clerodendrum colebrookianum* Walp., *Cinnamomum glanduliferum* Meisn., *Vernonia cinerea* Less, *Cissampelos pareira* Linn., *Scoparia dulcis* Linn., *Leucas lanata* Benth., *Leucas aspera* Spreng, *Laurus bejolghota* Buch. -Ham., *Piper betle* Linn., *Piper longum* Linn., *Piper nigrum* Linn., *Artocarpus lakoocha* Roxb., *Artocarpus heterophyllus* Lam., *Mangifera indica* Linn., *Adhatoda vasica* Linn., *Asimina obovata* (Willd.) Nash, *Centella asiatica* (Linn.) Urb., *Hydrocotyle sibthorpioides* Lam., *Lygodium japonicum* (Thunb.) Sw., *Naravelia zeylanica* (Linn.) DC., *Phlogacanthus thyrsiflorus* Nees, *Swertia chirayita* (Roxb.) Buch. -Ham. ex C. B. Clarke, *Ananas comosus* (Linn.) Merr., *Asclepias gigantea* Lam., *Capsicum frutescens* Linn., *Plumbago indica* Linn., *Plumbago zeylanica* (Linn.) Cav., *Oryza sativa* Linn., *Xanthium strumarium* Linn., *Croton caudatus* Geiseler, *Croton joufra* Roxb, *Lygodium flexuosum* (Linn.) Sw., *Pteridium aquilinum* Linn., *Sida rhombifolia* Linn., *Smilax perfoliata* Lour., *Acacia pennata* (Linn.) Willd., *Allium sativum* Linn., *Zingiber officinale* Roscoe, *Costus speciosus* (J.Koenig) Sm., *Alpinia malaccensis* (Burm.f.) Roscoe, *Gomphrena sessilis* Linn., *Cyprus* sp., *Desmodium* sp., *Phyllodium pulchellum* (Linn.) Desv., *Equisetum* sp., *Melastoma malabathricum* Linn., *Psidium guajava* Linn., *Pothos scandens* Linn., *Rubus* sp., *Saccharum officinarum* Linn., *Solanum torvum* Sw, *Solanum ferox* Linn., *Thunbergia cordifolia* Nees, *Zanthoxylum oxyphyllum* Edgew., *Hedyotis diffusa* Willd., *Thelypteris cylindrothrix* (Rosenst.) Iwatsuki, *Amomum aromaticum* Roxb., *Amomum corynostachyum* Wall., *Musa paradisiaca* Linn., *Buddleja asiatica* Lour., *Dysoxylum malabaricum* Linn., *Litsea monopetala* (Roxb. ex Baker) Pers. Khuwalu, and *Moringa oleifera* Lam.. A detailed beneficial role of ethnobotanically used plants during rice-based alcoholic fermented beverages is summarized in Table 3.

6. Traditional Rituals and Significance of Alcoholic Fermented Rice Beverages

Fermented beverages have the spiritual connection with cultural rituals of various ethnic communities of NE India. These beverages are not only a fundamental requisite in social and ritual occasions but are also used as refreshing drinks in various aspects [27]. It is used in numerous occasions such as worshipping God, harvesting agricultural crops, and commemorations of marriage and unity. It also signifies the habitat, origin, religion, dominant men or women, and root of the community [47]. Fermented alcoholic beverages increase the dietary protein, fibers, vitamins, and other essential minerals [125]. Most of the people use

Table 2: Health benefits of traditional alcoholic fermented rice-based beverages of North-East India.

Beverages	Health benefits	References
Jou bishi	Cures diseases such as jaundice, diarrhea, cholera, urinary disorder and gastrointestinal disorders; it keeps the body relaxes and healthy when consumed in adequate quantity; enhanced nutritional utilities; overexpressed butyric acid	[52]
Bhaati jaanr	Used as energy booster for postnatal women and old ailing people; used against bile and gastric stress, hydrophobicity; antimicrobial and antiproliferative properties	[53]
Po:ro apong	Prevents the formation of kidney stones and is used as energy booster, increasing the concentration of alcohol	[45, 58]
Atingba or Waiyu	Regulates the menstrual cycle of women and is used as a medicine for loss of appetite and obesity; inhibits lipid peroxidation; enhances the stability of shelf-life	[47, 62]
Judima	Enhances good sleep and good digestion; increases the mineral content	[19, 37]
Zutho or Zhuchu	Reduces fever, blood pressure, and helps in digestion and is used as energy booster; enhances the taste of sour and fruity aroma	[41]
Chubitchi	Consumed to reduce the pain of muscle fibers; can relieve gastrointestinal problems, stomach cramps, menstrual cramps among women, joint pain, and is an antiageing agent; it can cure various illnesses and has antihypertension, antioxidant, and antimicrobial properties	[51, 63]
Sadhier or Kiad	It cures the urinary problems and dysentery; it becomes a health tonic when consumed in small quantity on a daily basis	[13]
Choko or Jonga-mod	Enhances sleeping, relieves headache, and body ache, cures psychiatric patients, diarrhea, and other urinary problems; enhances the strength of body and curing of swollen legs in cattle	[30]
Langi or Chuwak	It prevents degenerative diseases, skin diseases, treating common cold and jaundice, nervous diseases	[49]
Opo	Remedies of urinary problems, diarrhea, inflammation, headache, insomnia, and body ache; it can improve gut-brain connection and develops positive vibe. It enhances the immune system, maintains cholesterol borderlines, and prevents other intestinal diseases	[41]

alcoholic beverages in the morning before breakfast and dinner for health benefits. Literature reported that alcoholic beverages, i.e., rice beer, have showed the efficacies against urinary problems, inflammation, and diarrhea [30, 40]. Moreover, fermented rice is a rich source of probiotics that provides an extremely great number of health benefits and is beneficial to consumers in future prospects. It contains a rich diversity of microbes, and these may be filamentous moulds such as *Mucor circinelloides, Mucor hiemalis, Rhizopus stolonifera, and Rhizopus chinensis;* yeast such as *Pichia anomala, Saccharomycopsis fibuligera, Saccharomyces cerevisiae, Candida glabrata, Saccharomycopsis capsularis, Pichia burtonii, Saccharomyces bayanus, Pichia guilliermondii, Pichia fabianii, Candida parapsilosis, Trichosporon* spp., *Candida tropicalis*, and *Torulaspora delbrueckii* and lactic acid bacteria such as *Pediococcus pentosaceus* and *Lactobacillus bifermentans* [22, 38, 44].

Moreover, AFRBs contain rich nutritional properties such as *Bhaati jaanr* contains 9.5% protein, 86.9% carbohydrate, 1.5% crude fiber, 2.0% fat, and 404.1 kcal/100 gm food value, 146.0 mg per 100 gm K, 595.0 mg per 100 gm P, 12.8 mg per 100 gm Ca, 7.7 mg per 100 gm Fe, 50.0 mg per 100 gm Mg, 2.7 mg per 100 gm Zn, and 1.4 mg per 100 gm Mn [38]. In *Apong* from Arunachal Pradesh, moisture content 87–90%, acidity 1.03–1.04, alcohol 4.2–5.5%, carbohydrate 7.0–8.5 g/100 g, ash 0.1–0. 3 g/100 g, and reducing sugar 5.1–6.0% [126]. In *Po:ro* apong, carbohydrate 46.62 mg/mL, reducing sugar 3.33 mg/mL, total protein 1.05 mg/mL, free amino acids 2.43 mg/mL, and ethanol content 7.52% [58].

However, alcohol content also varies from one beverage to another, such as *Xaj pani* (14.82%), *Jou bishi* (12.26%), *Apo* (18–25%), *Po:ro apong* (7.52%–18.5%), and *Bhaati jaanr* (4.8%) [58, 127]. These variations might be due to their respective preparation methodologies. Furthermore, consumption of AFRBs not only has a cultural practice but also provides a rich nutritional source [23].

7. Stability and Risk Factors Associated with Alcoholic Fermented Rice Beverages

The variability of alcohol, minerals, and carbohydrates in fermented rice beverages is most challenging among the ethnic communities. It is mainly due to the seasonal variability of used raw materials (rice, plants, and herbs) and environmental conditions. Moreover, there is no specific methodology for preparation of fermented alcoholic beverages within the same ethnic community [128]. It is shown that more inhibition of lipid peroxidation during the 3rd month of fermentation observed the different shelf-life of the beverages. The shelf-life of Manipuri rice beverage, *Atingba*, can be increased up to 3 months at 32°C [129]. Studies revealed that it is used as a natural preserving agent and food supplement. Moreover, supplementation of flavonoid extracts extends the shelf-life of fermented rice beverages [130]. Addition of sulfite can inhibit oxidation of rice beverage during storage that maintains the stability [131]. The uses of fermented rice beverages are most prevalent and attractive among the tribal tradition due to rich sources of antioxidants and nutrition. Although no scientific

Table 3: Plants used in starter cakes and traditional therapeutic uses in North-East India.

States	Fermented rice beverages	Starter cakes	Herbs/plants used in starter cake preparation and its health benefits	References
Arunachal Pradesh	*Opo/Kala apong*	*Siiyeh*	*Clerodendrum indicum* Linn.: inflammation, bronchitis, febrifuge, and cough. *Cissampelos pareira* Linn.: ulcer, wound, rheumatism, fever, asthma, cholera, diarrhoea, inflammation, snakebite, malaria, rabies, and blood purification	[20]
	Themsing	*Pham/Phab*	*Cinnamomum glanduliferum* Meisn.: cold, cough, pain, and diarrhea	[20]
	Nyongin/Chhang, arrak, kinnauri	*Opop*	*Vernonia cinerea* Less: inflammation, diarrhea, cough, asthma, Parkinson's diseases, and leprosy. *Amomum aromaticum* Roxb.: throat trouble, inflammation, digestive disorders, gastrointestinal disorders, and respiratory problems	[20, 73, 74]
	Sira-oa	*Paa*	*Cissampelos pareira* Linn.: ulcer, wound, rheumatism, fever, asthma, cholera, diarrhoea, inflammation, snakebite, malaria, rabies, and blood purification. *Clerodendrum viscosum* Vent.: tumors, skin diseases, snake bite, scorpion sting, intestinal infections, and kidney dysfunctions	[75]
	Apong	*Ipoh*	*Scoparia dulcis* Linn.: diarrhea, stomach ache, kidney stone, kidney problem, and fever. *Leucas lanata* Benth.: common cold, high fever, skin disease, headache, and conjunctivitis	[20, 76]
	Pona	*Ipoh/Siye*	*Leucas aspera* Spreng: pyretic and insecticide. *Piper betle* Linn.: bacterial, wound healing, mouth freshener, digestion, and pulmonary diseases. *Artocarpus lakoocha* Roxb.: antioxidant, inflammation, and skin ageing. *Mangifera indica* Linn.: diarrhea, dysentery, anaemia, asthma, bronchitis, cough, hypertension, insomnia, rheumatism, toothache, haemorrhage, and piles	[20, 31, 77]
Arunachal Pradesh/Sikkim	*Rakshi*	*Marcha*	*Artocarpus lakoocha* Roxb.: antioxidant properties, inflammation, and skin ageing. *Mangifera indica* Linn.: diarrhea, dysentery, anaemia, asthma, bronchitis, cough, hypertension, insomnia, rheumatism, toothache, haemorrhage, and piles	[20, 78]
Assam	*Apong*	*Apop pitha*	*Adhatoda vasica* Linn.: bronchitis, leprosy, blood disorders, heart troubles, asthma, fever, vomiting, loss of memory, leucoderma, jaundice, tumors, sore-eye, fever, and gonorrhea. *Actinodaphne obovata* (Nees) Bl: treats fractures. *Costus speciosus* (J.Koenig) Sm.: bacterial, hyperglycemic, inflammation, pyretic, arvicidal, stress, and estrogenic. *Centella asiatica* (Linn.) Urb.: wound healing, inflammation, ulcer, hepatoprotective, convulsant, sedative, immunostimulant, cardioprotective, diabetic, tumor, viral, bacterial, insecticidal, fungal, and antioxidant properties. *Hydrocotyle sibthorpioides* Lam.: fever, edema, dysentery, rheumatalgia, whooping cough, jaundice, throat pain, hepatitis-B infection, soothing pain, dysmenorrhea, and carbunculosis. *Lygodium japonicum* (Thunb.) Sw.: diuretic, cold, inflammation, kidney stones, and renal ailments. *Naravelia zeylanica* (Linn.) DC.: helminthiasis, dermatopathy, leprosy, inflammation, wounds, and ulcers. *Piper longum* Linn.: chronic bronchitis, asthma, constipation, gonorrhea, diarrhea, cholera, malaria, viral hepatitis, respiratory infections, stomachache, bronchitis, cough, and tumor. *Piper nigrum* Linn.: antioxidant, microbial, tumour, and inflammation properties. *Phlogacanthus thyrsiflorus* Nees: bacterial, fungal, diabetic, inflammatory, cancer, and hepatoprotective properties. *Scoparia dulcis* Linn.: diarrhea, stomach ache, kidney stones, kidney problems, and fever. *Swertia chirayita* (Roxb.) Buch.-Ham. ex C. B. Clarke: chronic fever, liver disorders, ceptic, urinary disorders, skin diseases, cough, hiccup, and poisoning	[29, 58, 79–87]
	Jonga-mod	*Bakhor/Surachi/Phap*	*Ananas comosus* (Linn.) Merr.: digestion, inflammation, seasickness, and sore throat. *Artocarpus heterophyllus* Lam.: bacterial, fungal, diabetic, inflammation, and antioxidant. *Asclepias gigantea* Lam.: anthelmintic, analgesic, astringent, inflammation, tumor, and digestion. *Capsicum frutescens* Linn.: cough, toothache, sore throat, parasitic infections, rheumatism, and wound healing. *Clerodendrum infortunatum* Linn.: bronchitis, asthma, fever, inflammation, burning sensation, and epilepsy. *Plumbago indica* Linn.: skin diseases, infection, intestinal worms, acne, sores, and ulcers. *Saccharum officinarum* Linn.: hemorrhage, inflammation, jaundice, and urinary tract problems. *Scoparia dulcis* Linn.: diarrhea, stomach ache, kidney stones, kidney problems, and fever	[30, 88–92]
	Jou bishi	*Emao/ Amao/Angkur*	*Clerodendrum infortunatum* Linn.: bronchitis, asthma, fever, inflammation, burning sensation, and epilepsy. *Oryza sativa* Linn.: cardiovascular disease, blood glucose regulation, obesity, type 2 diabetes, bacterial, and skin ageing. *Scoparia dulcis* Linn.: diarrhea, stomach ache, kidney stones, kidney problems, and fever. *Xanthium strumarium* Linn.: rhinitis, nasal sinusitis, headache, gastric ulcer, urticaria, rheumatism bacterial, fungal, and arthritis	[93–95]
	Xaj Pani/Koloh pani	*Vekur pitha/Xaj pitha*	*Oryza sativa* Linn.: cardiovascular disease, blood glucose regulation, obesity, type 2 diabetes, bacterial, and skin ageing. *Centella asiatica* (Linn.) Urb.: leprosy, lupus, ulcer, diarrhoea, fever, amenorrhea, genitourinary tract diseases, and anxiety. *Laurus bejolghota* Buch.-Ham.: stomach disorder, fever, urinary stone, toothache, bone fracture, wound healing, pain, skin diseases, arthritis, diarrhea, liver trouble, and bacterial. *Cissampelos pareira* Linn.: ulcer, wound, rheumatism, fever, asthma, cholera, diarrhoea, inflammation, snakebite, malaria, rabies, and blood purification. *Clerodendrum infortunatum* Linn.: bronchitis, asthma, fever, inflammation, burning sensation, and epilepsy. *Croton caudatus* Geiseler: liver diseases, fever, and sprain. *Hydrocotyle sibthorpioides* Lam.: brain tonic, detoxifying agent, and hepatoprotective. *Lygodium flexuosum* (Linn.) Sw.: jaundice, dysmenorrhea, and wound healing. *Naravelia zeylanica* (Linn.) DC.: helminthiasis, dermatopathy, leprosy, rheumatalgia, odontalgia, colic inflammation, wound, ulcer, cure cold, headache, migraine, itches and skin allergy, dermatitis, malarial fever and headache, and rhinitis. *Pteridium aquilinum* Linn.: weed control, animal bedding, cover mulch, insect repellent, fungal agent, and biofuel. *Piper nigrum* Linn.: antioxidant, microbial, tumour, and inflammation. *Sida rhombifolia* Linn.: diarrhea, malarial, gastrointestinal dysentery, fever, asthma, inflammation, bacterial, oxidant, and anxiety. *Smilax perfoliata* Lour.: toothbrush and blood purifier	[80, 87, 93, 94, 96–102]
	Arak/Hor alank	*Thap*	*Croton joufra* Roxb.: intestinal helminthic infections, fermenting liquor, and arrow poison. *Amomum corynostachyum* Wall.: flavor and fragrant, cooling, and refreshing. *Acacia pennata* (Linn.) Willd.: rheumatism, headache, and fever	[35, 103, 104]
	Sujen	*Perok kushi*	*Allium sativum* Linn.: indigestion, respiratory and urinary infection, cardiac disorder, carminative, antipyretic, sedative, aphrodisiac, and diuretic. *Zingiber officinale* Roscoe: headaches, indigestion, nausea, vomiting, cancer, autoimmune disease, hypertension, hypercholesteremia, hyperuricemia, and bacterial infection. *Oryza sativa* Linn.: cardiovascular diseases, blood glucose regulation, obesity, type 2 diabetes, bacterial, and skin ageing. *Scoparia dulcis* Linn.: diarrhea, stomach ache, kidney stones, kidney problems, and fever. *Naravelia zeylanica* (Linn.) DC.: helminthiasis, leprosy, dermatopathy, rheumatalgia, odontalgia, colic inflammation, wound, ulcer, cure cold, headache, migraine, itches and skin allergy, dermatitis, malarial fever and headache, and rhinitis. *Ananas comosus* (Linn.) Merr.: digestion, inflammation, seasickness, and sore throat. *Costus speciosus* (J.Koenig) Sm.: bacterial, hyperglycemic, inflammation, pyretic, arvicidal, stress, and estrogenic. *Artocarpus heterophyllus* Lam.: bacterial, fungal, diabetic, inflammation, and antioxidant. *Pteridium aquilinum* Linn.: weed control, animal bedding, cover mulch, insect repellent, fungal agent, and biofuel. *Alpinia malaccensis* (Burm.f.) Roscoe: stomachic, diarrhea, expectorant, rheumatism, wounds, sore, and ringworm. *Gomphrena sessilis* Linn.: arthritis, backache, diarrhea, constipation, and ulcer. *Capsicum annuum* Linn.: stomachic, toothache, poor circulation, fever, hyperlipidemia, heart disease, osteoarthritis, shingles, rheumatoid arthritis, diabetic neuropathy, fibromyalgia, and back pain. *Cinnamomum bejolghota* (Buch.-Ham.) Sweet: anthelmintic and cardiotonic agent. *Centella asiatica* (Linn.) Urb.: wound healing, leprosy, lupus, ulcer, diarrhea, fever, amenorrhea, female genitourinary tract diseases, anxiety, and cognition. *Cyprus* sp.: gastrointestinal, respiratory, blood disorder, menstrual irregularities, and inflammation. *Desmodium* sp.: asthma, typhoid fever, inflammation, malaria, infantile malnutrition, and dysentery. *Phyllodium pulchellum* (Linn.) Desv.: insect repellent, cancer, hemorrhages, fever, edema, liver injury, and viral infection. *Equisetum* sp.: genitourinary disease, inflammation, wound healing, rheumatic disease, prostatitis, and hypertension. *Lygodium flexuosum* (Linn.) Sw.: jaundice, dysmenorrhea, wound healing, and eczema. *Melastoma malabathricum* Linn.: diarrhea, dysentery, hemorrhoids, wounds, toothache, and stomach ache. *Psidium guajava* Linn.: gastrointestinal infection and indigestion. *Pothos scandens* Linn.: swelling, wound, muscle catches, sprain, bone fracture, blister, and diarrhea. *Rubus* sp.: wound, diarrhea, pain, diabetes, inflammation, and microbial agent. *Saccharum officinarum* Linn.: production of sugar, ethanol, and other industrial uses. *Solanum torvum* Sw.: fever, wound, tooth decay, reproductive problem, and hypertension. *Thunbergia cordifolia* Nees: pyretic, inflammation, and bacterial. *Zanthoxylum oxyphyllum* Edgew.: skin disease, rheumatism, ulcer, pain, fever, and hypotension	[36, 73, 99, 102, 105–113]
	Judima	*Humao*	*Hedyotis diffusa* Willd.: inflammation-linked diseases, such as hepatitis, appendicitis, and urethritis. *Solanum ferox* Linn.: fever, wound, toothache, cough, asthma, fever, vomiting, sore throat, and gonorrhea	[114–116]

Table 3: Continued.

States	Fermented rice beverages	Starter cakes	Herbs/plants used in starter cake preparation and its health benefits	References
Manipur	*Atingba/Waiyu*	*Hamei*	*Clerodendrum colebrookianum* Walp.: diabetes, hypertension, and other chronic diseases. *Dryopteris* sp.: inflammation, rheumatoid arthritis, wound, and ulcer	[116–118]
Meghalaya	*Chubitchi*	*Wanti*	*Plumbago zeylanica* (Linn.) Cav.: chronic rheumatoid arthritis, skin diseases, tumorous growth, menstrual disorders, and viral warts. *Clerodendrum infortunatum* Linn.: bronchitis, asthma, fever, inflammation, burning sensation, and epilepsy. *Thelypteris cylindrothrix* (Rosenst.) Iwatsuki: used in starter cake preparation	[116, 119]
	Kiad/Sadhier	*Thiat*	*Amomum aromaticum* Roxb.: throat trouble, inflammation, digestive disorders, gastrointestinal disorders, and respiratory problem. *Musa paradisiaca* Linn.: diarrhea, dysentery, intestinal ulcer, diabetes, nephritis, gout, hypertension, and cardiac disease. *Costus speciosus* (J.Koenig) Sm.: bacterial, hyperglycemic, pyretic, inflammation, arvicidal, stress, and estrogenic	[26, 40, 120]
Nagaland	*Zutho/Zhuchu*	*Piazu/Khrei/Khekhrii*	*Oryza sativa* Linn.: cardiovascular disease, blood glucose regulation, obesity, type 2 diabetes, bacterial, and skin ageing	[26, 94]
Sikkim	*Bhaati jaanr*	*Marcha*	*Buddleja asiatica* Lour.: fever, cough, sore throat, cold, stomach ache, diarrhea, malaria, dysentery, and other ailments. *Vernonia cinerea* (Linn.) Less.: inflammation, diarrhea, cough, smoking cessation, asthma, Parkinson's disease, and leprosy. *Zingiber officinale* Roscoe: headaches, indigestion, nausea, vomiting, cancer, autoimmune disease, hypertension, hypercholesteremia, hyperuricemia, and bacterial infection	[74, 75, 121]
Tripura	*Langi/chuwak*	*Chuwan*	*Dysoxylum malabaricum* Bedd. ex C. DC.: Rheumatic, eye and ear diseases, inflammation, cardio disorder, CNS disorder, and tumor. *Litsea monopetala* (Roxb. ex Baker) Pers. Khuwalu: Gonorrhea, skin disease, and arthritis. *Moringa oleifera* Lam.: Asthmatic, diabetic, fertility, hepatoprotective, inflammatory, cancer, microbial, oxidant, cardiovascular, ulcer, allergic, wound healing, analgesic, and pyretic. *Saccharum officinarum* Linn.: production of sugar, ethanol, and other industrial uses	[49, 122–124]

documentation has been available so far on direct consumption of fermented rice beverage in traditional customs, the plants or herbs that are used in the fermentation process have huge medicinal properties in the traditional healthcare system among the ethnic communities. These traditionally processed beverages are believed to have medicinal value in North-East India. Scientific intervention is required to improve the quality and functionality of traditional fermented rice beverages. However, intervention of modern techniques has led to several hindrances in the ethnic process and compromises the beneficial quality of beverages due to uses of synthetic chemicals and fertilizers for economic purposes. Moreover, raw materials that are used during fermentation, such as rice, plants, and herbs, are also affected due to uses of beyond the permissible limit of pesticides and fertilizers. Moreover, the commercial production of AFRBs faces a significant hurdle, the inconsistency in quality, and uniformity of the end product. The intrusion of diverse microflora introduces both temporal and spatial variations, resulting in changes to the biochemical compositions. A major stumbling block includes challenges in maintaining aseptic conditions, ensuring controlled fermentation, countering harmful microflora, and managing byproducts during the fermentation process [23]. In addition, the timing of harvesting the plants used in the starter cake preparation plays a crucial role, adding another layer of variability. To overcome these obstacles and achieve the desired quality, an optimized collection time for the plants and a precise preparation protocol are imperative for the fermentation process.

The product standardization of AFRBs is very much needed to maintain uniform qualities, textures, and flavour. To optimize these methodologies and parameters is very challenging during the preparation of AFRBs. However, several studies reported that the variability of parameters can vary in the production of end products following the fermentation process. Pakuwal and Manandhar [132] reported on the optimization of the fermentation method and raw materials based on the three parameters such as pH, temperature, and brix. They found that the maximum fermentation was observed at pH 3.5 followed by pH 5 and then pH 7, and the optimum growth was at 28°C, followed by 37°C [132]. Similarly, Salari and Salari [133], Ho and Powel [134], and Yalcin and Ozbas [135] reported that the growth of *Saccharomyces cerevisiae* and other strains of *Saccharomyces cerevisiae* increased at pH 4 and temperature (25–35°C) during ethanol production [133–135]. Le and Le [136] and Chay et al. [137] reported that alcoholic content (13.5–16.0%) and brix content (9–18 °Bx) were found at pH (3.3–5.0) in AFRBs of different varieties of rice [132, 137]. The optimization of fermentation methods and raw materials, as demonstrated in various studies, followed the complex interplay of parameters such as pH, temperature, and brix in the production of AFRBs.

8. Conclusion

North-East India is a reservoir of rich natural resources and has diverse traditional and cultural heritages where ethnic communities are using traditional fermentation processes for the preservation of food and alcoholic beverages for longer purposes since ancient times. Among them, the alcoholic fermented rice beverage is very common and is most popular among the ethnic communities, and it is the product of an association of yeast with variety of rice along with various ethnomedicinal plants. The microbial diversities also show the beneficial activity in the healthcare system due to the uses of medicinal plants or herbs in the cake during the process of fermentation. The products of fermentation are mostly of microbial origin that helps the health of consumers in daily life, and beverages are processed mainly by yeast and *Lactobacillus* bacteria which enhance the fermentation. However, inconsistency of the fermented product such as the presence of toxic metabolites that may lead to variable texture, odor, and turbidity that makes unsuitable [44]. To mitigate the damage of beverages, standardized technologies should be required for production of respective rice beverage among the communities which maintain the proper production of beverages. Moreover, most of the fermented alcoholic beverages are prepared at home, and the quality of the beverages cannot be maintained in the same taste and flavor in all the seasons due to changes in temperature and other abiotic factors. In addition, the hygienic conditions are also influencing the quality of the fermented beverages such as raw materials and other ingredients that are used during the preparation. Further identification and characterization of the microbes may stabilize the production processes in a constant environment which can be commercialized by the products. However, a proper documentation is needed for the processing of rice beverages along with preparation of starter cakes and usage of ethnomedicinal plants of different ethnic communities and that will improve the quality of beverages in a scientific way. Moreover, fermented rice-based beverages might be an opportunity for every household to boost the economy on the respective community as well as the society.

Data Availability

No data were used to support the findings of this study.

Ethical Approval

This article does not contain any studies with human participants or animals.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

Rikraj Loying conducted conceptualization, original draft preparation, writing of the review, editing, and visualization; Jatin Kalita conducted supervision and validation; Prasenjit Manna performed conceptualization, supervision, original draft preparation, writing of the review, editing, and validation. All the authors have read the final version of the manuscript and have given consent for publication.

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