International Journal of Pharmacognosy and Pharmaceutical Research

ISSN Print: 2664-7168
ISSN Online: 2664-7176
Impact Factor: RJIF 8
IJPPR 2024; 6(2): 21-27
www.pharmacognosyjournals.com
Received: 20-05-2024
Accepted: 17-06-2024

Dr. Sonali Ray
Department of Tea Science, University of North Bengal, Raja Rammhunpur, Darjeeling, West Bengal, India

Chitralekha Mahato
Department of Tea Science, University of North Bengal, Raja Rammhunpur, Darjeeling, West Bengal, India

Corresponding Author:
Dr. Sonali Ray
Department of Tea Science, University of North Bengal, Raja Rammhunpur, Darjeeling, West Bengal, India

Bioactive compounds in traditional fermented beverages from eastern and north eastern India: Preparation, composition, and health benefits

Dr. Sonali Ray and Chitralekha Mahato

DOI: https://doi.org/10.33545/26647168.2024.v6.i2a.73

Abstract
Traditional fermented beverages are intricately tied to the culture and heritage of indigenous groups worldwide. The methods and components involved in crafting alcoholic drinks vary depending on the availability of raw materials in distinct locales. The majority of these beverages are cereal-based, often incorporating indigenous plant elements to lend a unique flavor profile. These ethnically fermented drinks contain bioactive compounds with potential nutraceutical and therapeutic properties. Local starter cultures, composed of a variety of wild herbs, are employed in the beverage-making process, each with its own documented medicinal benefits. This review paper highlights the abundant ethno medicinal qualities of these plants. Rice emerges as the predominant substrate for beverage production among most tribal communities, while finger millet, barley, and sugarcane are used in smaller quantities. Of all plant parts, leaves are found to be the most utilized in creating starter cultures, whereas stems are least employed. These beverages offer notable health advantages due to the diverse plant components in the starter cultures. The present review focuses into the preparation, chemical composition, and medicinal properties of these beverages.

Keywords: Fermented beverages, health benefits, starter culture cake, medicinal plants, chemical constituents

Introduction

A beverage refers to a liquid concoction specifically crafted for human consumption, often providing energy in the form of sugar or alcohol. Among various tribal communities in India, the traditional making of alcoholic drinks is a common household tradition. The practice of naturally fermenting foods has been widely embraced since ancient times. The geographical setting of these tribal communities greatly influences the choice of local herbs and substrates. In the North-Eastern (N.E.) states of India, many tribal communities engage in the preparation and consumption of traditionally made rice beer, using diverse rice varieties along with plants, fruits, and flowers. Each tribe develops its unique starter culture cakes for fermentation, blending different parts of various plants. The shapes and sizes of these starter cultures may vary among different tribal groups [1] .Fermentation, a natural process where carbohydrates are transformed into alcohol and other compounds by anaerobic microbes, is a biological oxidation method utilized by specific microorganisms for their energy needs [2].

For the tribal communities in developing countries, fermented food holds significant importance due to its cost-effectiveness, especially as many tribes spend their lives in forest environments, relying on fermented products [3].

In Northeast India, various ethnic tribes regularly consume rice beer in different forms, attributing numerous therapeutic and medicinal properties to it. Nearly all tribes have their version of the traditional drink, each differing significantly in name, ingredients, and preparation methods, often passed down orally through generations. Rice beer plays a vital role in the socio-cultural fabric of tribal communities, being associated with occasions such as celebrations, ritual ceremonies, festivals, weddings, and even funerals [1].

These traditional alcoholic beverages are believed to offer notable health benefits, aiding in the prevention and treatment of gastrointestinal diseases, insomnia, headaches, diarrhea, body aches, inflammation, expelling worms, cholera, and urinary problems [4-7].

Reports from Northeast India suggest that rice beer contains nutritional and antioxidant properties due to compounds such as phenolic acids, polyphenols, and flavonoids [5]. Ethnic beverages, typically containing lower alcohol content than commercial liquors like whiskey, rum, and brandy, are often categorized as beer and wine. These traditional practices have offered valuable insights to the modern liquor industry. However, many of these age-old ethnic practices remain undocumented, leading to a lack of scientific analysis [8].

This review aims to explore the diverse methods of starter culture preparation across different communities, the essential plant ingredients for starter cultures, and the types and preparation techniques of substrates. It also seeks to understand the varied methods of preparing fermented beverages by ethnic groups in the eastern and north-eastern regions of India, summarizing their sources, chemical compositions, and health advantages.

Making starter cultures by diverse ethnic communities

Starter cakes and alcoholic beverages acquired different names in different tribal dialects but the preparation of starter cakes in all communities is almost the same.

Bakhar is a mixture of various plant parts and powdered rice. For Bakhar preparation various plant ingredients are collected from the local forest and their parts are dried and mixed with rice to prepare dough for making bakhar [9]. Umhu or humao is a mixture of rice and various plant parts used by dimasa tribe for judima beverage preparation. Glutinous rice is soaked in water until it is softened. It is then ground in a wooden or metallic mortar and pestle called rimin along with the bark of thempra plant. The old rice cake (15-20 g) was then powdered and mixed with the new rice cake. New rice cake is then kept in dark for at least 24 hours, and then it is sun- dried till it becomes hard properly [10]. Emao is the starter cake prepared by bodo community of Assam to produce rice beer called Zu, which are prepared from husked rice. The mishing tribal population prepares rice beer from starter cakes made of rice flour mixed with dry powdered leaves of different plants and in addition to which they add seeds of *Piper longum*. They use half-boiled sticky rice as substrate and directly mix it with starter culture kusure but sometimes they add rice husk with the above preparation. The former is known as nagin-apong and later as poro-apong.

For eu preparation moaa serves as a source for microorganisms which are added for the initiation of fermentation. Moaa is made up of locally grown rice powder and variations come with the addition of formulated medicinal plants. Rice cakes are made with variable diameters. Charcoal is added to the rice cakes to prevent fungal growth. The old starter culture is sprinkled over the new one. Then finally the “moaa” is sun-dried and moaa is ready for use [11]. Amao is traditionally prepared starter cake from plant parts and soaked rice grain. A little amount of previously prepared amao which acts as an inoculant is mixed with the powder. A little amount of water is added to make a sticky paste and then made into a small round flat cake. The cakes are then kept on clean, dry paddy straws spread on a songrai (a round bamboo craft) and again covered with straws. This process continues for a couple of weeks until the amao becomes hard; these are ready to be used in brewing rice beer [12]. For the preparation of epop, glutinous rice soaked in water for about 2 hrs, ground together, and mixed properly with semi-dried powder of leaves or the whole plant/plant parts. A little amount of water is added for making dough followed by the preparation of oval-shaped balls [13]. That’s how starter culture is made by different tribes from different origins in India.

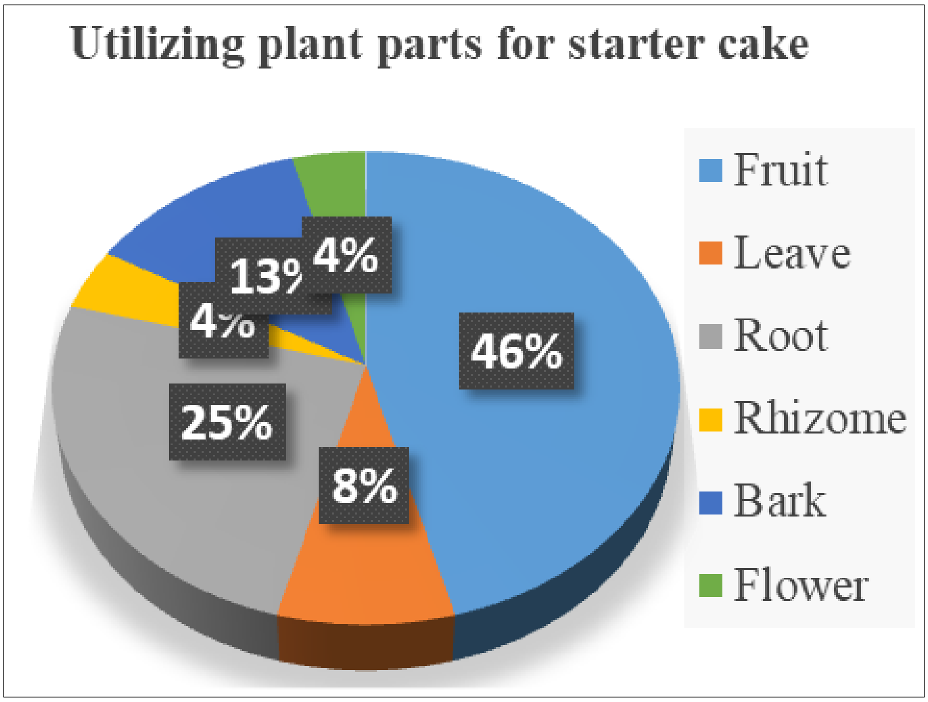

Fig 1: Plant parts used for the creation of starter culture cake

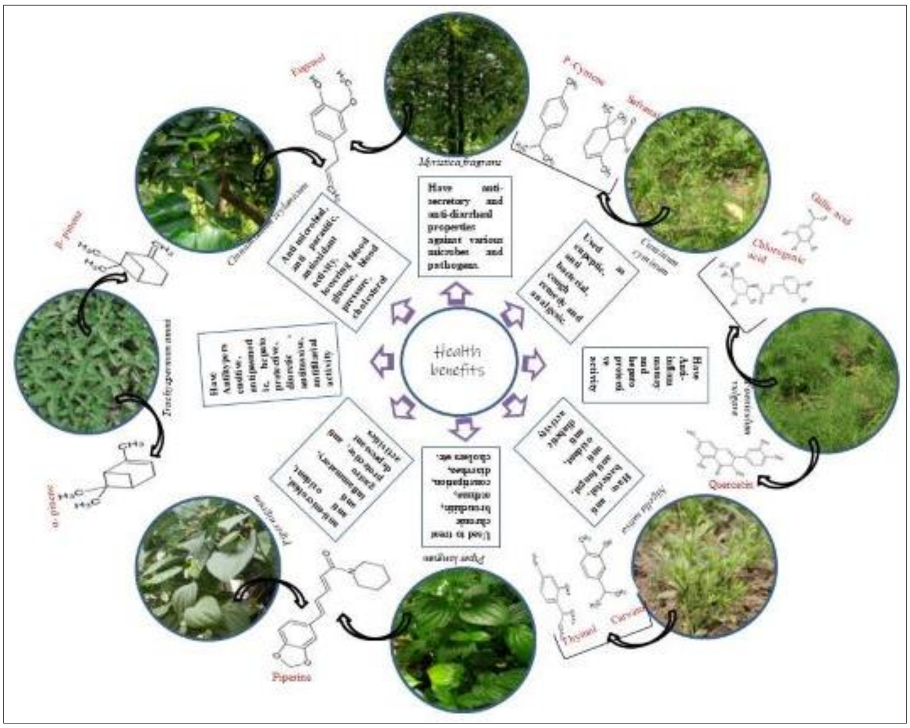

Fig 2: Key plant compounds and their positive effects on health

Crafting traditional drinks from various cultures

Judima

For preparing judima rice is boiled and allowed to cool. It is mixed with powdered humao, one large-sized humao is sufficient for 5 Kg of rice and kept in a large container which is covered with jute gunny bags. After 5-7 days, slightly yellowish juices come out from the fermented mass which indicates the completion of the fermentation process. This can further be diluted with water and filtered for consumption [4].

Apong

Apong is a mixture of rice and starter cake apop pitha. The earthen pot is used as a fermentor and before starting the fermentation process, it is fumigated by placing it on a bamboo frame constructed over the fireplace until the pot turns blackish. Thereafter the boiled rice is spread over a large banana leaf and allowed to cool. To this, powdered apop pitha is added (1 apop pitha for 1 kg of rice) and the whole mixture is kept inside the fermentor and the mouth of the pot is covered with banana leaves. The fermentor is left for at least 5 days. A little water is added to the fermented product and is filtered to get the apong [1].

Rice beer from Tripura

Rice is cooked and spread over a mat for 1 to 2 hours for cooling. After cooling, an appropriate amount of starter culture (chuwan beleb) is mixed with cold-cooked rice of approximately 50 g in 1 kg. The mixture is placed in a container and covered with banana leaves so that minimum vapors can escape out of the container, covered with some rug or old clean cloth, and kept for 3 days. After 3 days, water is added and kept again for 2 days. The water is extracted and consumed as un-distilled rice beer. For distilled rice beer, the mixture is heated, and the vapor is collected in another container placed on top of the container. The vapors are allowed to pass through a bamboo into another container containing cold water for distilled rice beer. This rice beer is named sarak in Reang, chuwak in Debbarma, Jamatia, koloi in Tripuri, and zu in Molsom [14].

Handia

The method of Handia preparation is described by Ghosh *et al*., 2014 [15]. 1st impurities are removed from rice grain and then boiled. Cooling and drying are sequentially done by spreading on a clean mat. Then Bakhar is added to the rice grain otherwise the ferment will rot. Now a pouring mixture of rice grain and Bakhar is kept in an earthen pot which is tightly closed with its lid. The pot is then incubated for 3-4 days at room temperature. Finally, the cream-colored, buttermilk-like filtrate is ready for drinking.

Mahua beverage

Mahua distilled beverage is prepared from the dried flower of *Madhuca indica*. Dried flowers are kept in a pot where some water is added. The pot is closed with an airtight cloth and kept for 4-6 days till it starts smelling. 3 pots are required and piled one above the other. The lowest one contained fermented rice, the middle one remained empty with several pores at the bottom, and the upper one was filled with cold water. A pipe is inserted at the side bottom of the middle pot. The entire set is done on an earthen oven through a heating process. After heating, the vapor goes up from the lower pot to the middle one through the pore and comes in contact with the upper one containing cold water. Due to cooling, water vapor condenses into the water which comes down and is collected in a bottle through the pipe. This watery-colored beverage gives an alcoholic odor known as chullu or mod [16].

Therapeutic uses of some ethnic beverages

Chhang, a renowned beverage crafted from barley, is a favorite among the tribal communities of Sikkim and Darjeeling. Chhang contains ethanol, lactic acid, reducing sugars, phenolics, and furfurals. It has been documented that chhang is utilized for addressing issues such as coughs, dysentery, fevers, colds, and stomach ailments [17]. The phenolic compounds found in apong, sujen, and xajpani are noted for their antibacterial, anti-inflammatory, antispasmodic, antidiarrheal, antiviral, anticarcinogenic, and anti-allergic properties [18].

Apong is effective against a range of health concerns including gastrointestinal issues, skin ailments, respiratory problems, diabetes, and jaundice. The extract of 'kodo ko jaanr' is consumed by those recovering from illness and postnatal women due to its high caloric content [19]. Eu, crafted by the Toto tribes from finger millet, contains chemical compounds with antimicrobial, anti-inflammatory, anticancer, and anti-arthritic properties. It aids in preventing water loss and supports hepatic function [20].

Sujen plays a significant role in stabilizing lipid peroxidation, inhibiting various oxidizing enzymes, and is beneficial for gastrointestinal problems, skin conditions, respiratory ailments, diabetes, jaundice, and is regarded as an energy booster [21]. Chuwak, a distilled beverage containing alcohol, reducing sugars, carbohydrates, and alkaloids, provides protection against colds. The alkaloids exhibit potent antioxidant activity and possess various pharmacological benefits such as anti-malarial, antiasthma, anticancer, and antibacterial properties [14, 5].

Handia, administered to children during stomach ache, diarrhea, dysentery, and jaundice, is also known for its cooling properties during the summer. Some women consume it to address gynecological issues as a medicinal remedy. This non-toxic, economical product is used as a dietary supplement and remedy for skin, eye, hair, and heart health. Plant parts used in the preparation of chullu are employed to treat chronic diarrhea, dysentery, bleeding piles, urinary troubles, and other ailments. These plants hold immense value and could serve as an alternative strategy for survival among economically disadvantaged populations [22].

The Mahua beverage aids in treating eye diseases and exhibits analgesic, hepatoprotective, and anti-helminthic properties [23].

Table 1: Active components present in the ethnic fermented beverages

Beverage	Substrate	Bioactive components	References
Judima	Rice	Carbohydrat es, protein, phenols, flavonoids, saponins, terpenoids, glycosides	[24,4]
Chhang	Barley	Ethanol, lactic acid, reducing sugars, phenolics, furfurals content	[17, 25,26, 27]
Apong	Rice	Phenolic compounds (gallic acid,catechin, caffeic acid, p-coumaric acid, ferulic acid)	[28, 29, 30]
Kodo ko jaanr	Finger millet	Alcohol, lactic acid, reducing sugar, carbohydrate, protein, crude fibre, valine	[31, 32, 18]
Choko	Rice	Reducing sugar, carbohydrate, crude protein, ascorbic acid, alkaloids, flavonoids, cardiac glycosides, phenols, saponins	[7, 33, 34]
Jou	Rice	Carbohydrat e, protein, sugar, phenols, tannins, anthraquinones etc	[6, 35]
Hor arak	Rice	Alcohol, protein, carbohydrate, cardiac glycosides, phenols, tannins, saponins, flavonoids	[34,36, 3]
Eu	Finger millet	2- hydroxyprop anoic acid, Ethyl alpha- d- glucopyrano side, octadecanoic acid, cis-9- hexadecenal, 9-octadecenal	[20, 37, 38, 39]
Sujen	Rice	Phenolic compounds	[21]
Xajpani	Rice	Phenolic compounds (gallic acid, catechin, caffeic acid, p-coumaric acid, ferulic acid	[40]
Chuwak	Rice	Alcohol, reducing sugar, non- reducing sugar carbohydrate	[12, 14, 41]
Handia	Rice	Alcohol, Lactic acid, Minerals, Phenolic compound	[15, 42]

Table 2: Plants used in preparation of starter cake and their health benefits

Starter cake	Plants used	Health benefits	References
Umhu/hu mao (judima)	*Acacia pennata, Piper betle, Buddleja asiatica, Hedyotis scandens*	Used in the treatment of diseases and physiological disorders.	[4, 26, 43]
Balma (Chhang)	*Cinnamomum zeylanicum, Ammomum subulatum, Piper longum, Ficus religiosa, Humulus lupulus, Inula cuspidate, Micromeria biflora, Origanum vulgare, Rubus sp, Thymus linearis*	Used in the treatment of cough, dysentery, fever, cold, and stomach ailments.	[27, 26]
Apop pitha (Apong)	*Ananus comosus, Artocarpus heterophyllus, Adhatoda vasica, Actinodaphne obovate, Cinnamomum tamala, Costus specious, Centella asiatica, Drymeria cordata, Hydrocotyl rotundifolia, Hydrocotyle sibthorpioides, Ipomoea mauritiana, Kaempferia rotunda, Lygodium flexosum, Lygodium japonicum, Melothrea heterophylla,Musa balbisiana* *Naravelia zeylavica, Oldenlandia corymbose, Oryza sativa, Piper longum, Piper nigrum, Phogocanthus thyrsiflorus, Pteridium aquilinum, Scoparia dulcis, Selaginella sp, Swertia chirata,*	Phenolic compounds have been reported to have anti-bacterial, anti-inflammatory, antispasmodic, anti-diarrheic, antiviral, and anti- allergic properties and having antioxidant effect. Helps in stabilizing lipid peroxidation and inhibition of various oxidizing enzymes. Phenolic compounds have been reported to have anti-bacterial, anti-inflammatory, antispasmodic, anti-diarrheic, anti- viral, and anti-allergic properties and having antioxidant effect. Helps in stabilizing lipid peroxidation and inhibition of various oxidizing enzymes. Also effective against gastrointestinal problems, skin disease, respiratory ailments, diabetic problems and jaundice.	[44, 45, 7]
Marcha (kodo ko jaanr)	*Plumbago zeylanica, Buddleja asiatica, Vemonia cinerea, Zingiber officinale*	Because of high calorie, ailing persons and post- natal women consume the extract of kodo ko jaanr to regain strength.	[5, 46]
Bakhar/s uruchi/P hab (choko)	*Ananas comosus, Artocarpus heterophyllus, Calotropis gigantean, Capcicum fructescens, Cleodendrum viscosum, Dennstaedtia scabra, Ochthochloa coracana, Plumbago indica, Saccharum officinarum, Scoparia dulcis, Sida rhombifolia,*	Known for relieving headaches, body pain, inflammation, diarrhea, and even urinary problem. Have antioxidant activity.	[7, 44, 47, 48]
Angkur/ Amao (jou)	*Clerodendron infortunetum, Oryza sativa, Scoparia dulcis, Xanthium strumarium, Musa paradisiaca, Artocarpus heterophyllus, Ananus comosus, Plumbago zeylanica, Capsicum*	Helpful against jaundice, diarrhoea, stomach worms, cholera, gastrointestinal disorder, urinary disorders etc.	[44]

	annum		
Thap (Hor arak)	*Clerodendrum viscosum, Solanum indicum, Cymbopo- gon citratus, Ricinus communis, Zingiber officinale, Artocarpus heterophyllus, Ananas comosus, Physalis peruviana, Olax acuminate, Xanthium strumarium,*	Used as a medicine in dysentery and pharyngitis. Effective against the epidemic of cholera. Have antioxidant activity.	[49]
Moaa (Eu)	*Eleusine coracana, Oryza sativa, Capsicum annuum, Pterospermum acerifolium, Plumbago zeylanica Drymaria cordata, Athyrium nigripes*	Antimicrobial, Prevent water loss, cure hepatic function disorder. Anti-inflammatory, anticancer anti- arthritic, Antimicrobial, Anti- inflammatory.	[5-54]
Mod pitha (sujen)	*Allium sativum, Artocarpus heterophyllus, Ananus comosus, Alpinia malaccensis, Alternanthera sessilis, Cinnamomum bejolghota, Costus specious, Centella asiatica, Coffea bengalensis, Cyperus sp, Capsicum annum, Drymeria cordata, Desmodium sp, Desmodium pulchellum, Equisetum sp, Lygodium flexuosum, Melastoma malabathricum, Mussaaenda roxburghii*	Reported to have anti-bacterial, anti-inflammatory, antispasmodic, anti-diarrheic, anti-carcinogenic properties. Removes tiredness and relaxes the body.	[5, 21, 46]
Vekhur pitha (xajpani)	*Centella asiatica, Cinnamomum bejolghota, Cissampelos pareira, Cledendrum viscosum, Croton caudatus, Hydrocotyle sibthorpioides, Hedyotis corymbosa, Lygodium flexuosum, Naravelia zeylanica, Oryza sativa, Pteridium aquilinum, Piper nigrum, Sida rhombifolia, Smilax perfoliata*	Have anti- bacterial, anti- inflammatory, antispasmodic, anti-diarrheic, anti- viral, anti-allergic properties, antioxidant. Stabilizing lipid peroxidation and inhibition of various oxidizing enzymes. Effective against gastrointes- tinal problem, skin disease, respiratory ailments, diabetic problems and jaundice. Energy drink, relieves body ache, urinary disorders, dysentery, headache.	[1, 6, 55-57]
Chuwan beleb (chuwak)	*Moringa oleifera, Dysoxylum blume, Markhami astipulata, Artocarpus heterophyllus, Saccharum officinarum, Litsea monopetala*	Protection against Cold. Alkaloids show strong antioxidant activity. It has anti-malarial, antiasthma, anticancer and antibacterial properties.	[58-60]
Bakhar (handia)	*Cissampelos Pareira, Ruellia tuberosa, Lygodium smithianum, Madhuca longifolia, Elephantopus scaber, Holarrhena pubescens, Andrographis paniculta, Asparagus racemosus, Acorus calamus Symplocos racemose, Piper longum, Hemidesmus indicus, Cassia senna, Polygala crotalariodes, Oscimum basilicum, Rubia cordifolia, Parmelia perlata*	Presence of phenolics and flavonoids can correlate with free radical scavenging and anti-mutagenic property of the product that prevents risk of heart disease. Used as a remedy for skin, eye and hair and heart- protective agent. Used to treat fever, dysentery, Diarrhea and gynecological complaints.	[61-68]

Discussion
The primary compounds in traditionally crafted drinks include alcohol, sugars, carbohydrates, proteins, and vitamins, common to nearly all fermented ethnic beverages. Additionally, some beverages also contain phenolic compounds, glycosides, sterols, terpenes, alkaloids, and anthraquinones. These beverages are rich in nutrients and believed by tribes to offer protection against colds. They are thought to prevent headaches, insomnia, urinary issues, body aches, and cholera. Among all substrates, rice is the most frequently used for beverage production, compared to finger millet and barley.

Conflict of interest
There are no conflicts of interest declared by the authors.

Acknowledgements
The authors appreciate the support provided by the Department of Tea science, North Bengal University and the CSIR organization for providing the financial support to complete this review work.

References

1. Das AJ, Deka SC, Miyaji T. Methodology of rice beer preparation and various plant materials used in starter culture preparation by some tribal communities of North-East India: A survey. Int Food Res J. 2012 Jan;19:101-107.
2. Kuwaki S, Nakajima N, Tanaka H, Ishihara K. Plant-based paste fermented by lactic acid bacteria and yeast: Functional analysis and possibility of application to functional foods. Biochem Insights. 2012 Oct;5:21-29.
3. Teron R. Hor, the traditional alcoholic beverage of Karbi tribe in Assam. Nat Prod Rad. 2012 Jan;5(5):377-381.
4. Prakash D, Gupta C, Sharma G. Importance of phytochemicals in nutraceuticals. J Chin Med Res Dev. 2012 Jan;1:70-78.
5. Nath N, Ghosh S, Rahaman L, Kaipeng DL, Sharma BK. An overview of traditional rice beer of North-East India: Ethnic preparation, challenges, and prospects. Indian J Tradit Knowl. 2019 Oct;1:744-757.
6. Samati H, Begum SS. Kiad, a popular local liquor of Pnar tribe of Jaintia Hills District, Meghalaya. Indian J Tradit Knowl. 2007 Jan;6(1):133-135.
7. Deka D, Sarma GC. Traditionally used herbs in the preparation of rice-beer by the Rabha tribe of Goalpara District, Assam. Indian J Tradit Knowl. 2010 Jul;9(3):459-462.
8. Egea T, Signorini MA, Ongaro L, Rivera D. Traditional alcoholic beverages and their value in the local culture of the Alta Valle del Reno, a mountain borderland between Tuscany and Emilia-Romagna (Italy). J Ethnobiol Ethnomed. 2016 Jun 22;12(1):27.
9. Ghosh S, Sen SK, Mondal S. Ethnobotanical perspectives of Ba-khar: An indigenous starter culture used to prepare traditionally fermented rice beverage in rural West Bengal, India. J Ethnic Foods. 2022 Dec;9:26.
10. Arjun J, Verma AK, Prasad SB. Method of preparation and biochemical analysis of local tribal wine Judima: an indigenous alcohol used by Dimasa tribe of North Cachhar Hills District of Assam, India. Int Food Res J. 2014 Jan;21(2):463-470.
11. Bhattacharjee S, Kar P, Sarkar I, Sen A, Ghosh C. Biochemical and microbial profiling establish "Eu" (a traditional fermented beverage of Toto people) as a probiotic health drink. J Ethnic Foods. 2021 Aug;8(1):1-13.

12. Basumatary TK, Basumatary RT, Medhi S, Bose S, Begum RS. Biochemical analysis of Jou: a traditional drink of the Boro tribe of Assam and Northeast India. IOSR J Environ Sci Toxicol Food Technol. 2014 Jan;8:99-103.
13. Gogoi B, Dutta M, Mondal P. Various ethno-medicinal plants used in the preparation of Apong, a traditional beverage used by the Mising tribe of Upper Assam. J Appl Pharm Sci. 2013 May;3(4):85-88.
14. Ghosh G, Rahaman L, Kaipeng DL, Deb D, Nath N, Tribedi P, *et al*. Community-wise evaluation of rice beer prepared by some ethnic tribes of Tripura. J Ethnic Foods. 2016 Dec;3:251-6. DOI: 10.1016/j.jef.2016.12.001
15. Ghosh K, Maity C, Adak A, Halder SK, Jana A. Ethnic preparation of Haria, a rice-based fermented beverage, in the province of lateritic West Bengal, India. Ethnobot Res Appl. 2014 Mar;12:39-49.
16. Saha MR, Ritu RAI, Kar A. Ethnobotany, traditional knowledge, and socioeconomic importance of native drink among the Oraon tribe of Malda District in India. J Intercult Ethnopharmacol. 2015 Sep;4(1):43-49.
17. Perveen K, Alabdulkarim B, Arzoo S. Effect of temperature on shelf life, chemical, and microbial properties of cream cheese. Afr J Biotechnol. 2011 Nov;10:16929-16936.
18. Zhang A, Wan L, Wu C, Fang Y, Han G, *et al*. Simultaneous determination of 14 phenolic compounds in grape canes by HPLC-DAD-UV using wavelength switching detection. Molecules. 2013 Sep;18:14241-14257.
19. Thapa S, Tamang JP. Product characterization of kodo ko jaanr: Fermented finger millet beverage of the Himalayas. Food Microbiol. 2004 Oct;21:617-622.
20. Bansal A, Kumar P, Narasimhan B. Synthesis, antimicrobial evaluation, and QSAR studies of 2-hydroxy propanoic acid derivatives. Drug Res. 2014 May;64(5):240-245.
21. Deori C, Begum SS, Mao AA. Ethnobotany of Sujen-a local rice beer of Deori tribe of Assam. Indian J Tradit Knowl. 2007 Jan;6:121-125.
22. Singh PK, Singh KI. Traditional alcoholic beverage, Yu, of Meitei communities of Manipur. Indian J Tradit Knowl. 2006 May;5(2):184-190.
23. Patel PK, Prajapati NK, Dubey BK. Madhuca indica: A review of its medicinal property. Int J Pharm Sci Res. 2012 Jan;3(5):942-950.
24. Yadav RNS, Agarwala M. Phytochemical analysis of some medicinal plants. J Phytol. 2011 Dec;3:10-14.
25. Miller GL. Use of dinitrosalicylic acid reagent for determination of reducing sugars. Anal Chem. 1959 Mar;3:426-428.
26. Kishor K, Tewari LM, Tewari A, Upreti BM. Traditionally fermented alcoholic beverages of high altitude Bhotiya tribal community in Kumaun Himalaya, India. Afr J Food Sci. 2013 Dec;7(12):508-510.
27. Bhatt KC, Silas RA. Traditional beverages and their importance in the folk life of Bhotiyas in U.P. Himalaya. J Himal Stud Reg Dev. 1990;13-4:56-62.
28. Gu¨lc¸in I˙. Antioxidant activity of food constituents: An overview. Arch Toxicol. 2012 Mar;86:345-391.
29. Shan B, Cai YZ, Sun M, Corke H. Antioxidant capacity of 26 spice extracts and characterization of their phenolic constituents. J Agric Food Chem. 2005 Oct;53:7749-7759.
30. Cos P, Ying L, Calomme M, Hu JP, Cimanga K, *et al*. Structure-activity relationship and classification of flavonoids as inhibitors of xanthine oxidase and superoxide scavengers. J Nat Prod. 1998 Jan;61:71-76.
31. Somogyi M. A new reagent for the determination of sugars. J Biol Chem. 1945 Sep;160:61-68.
32. Tamang JP, Nikkuni S. Selection of starter culture for production of kinema, a fermented soybean food of the Himalaya. World J Microbiol Biotechnol. 1996 Nov;12:629-635.
33. Sumner JB, Graham VA. Dinitrosalicylic acid: A reagent for the estimation of sugar in normal and diabetic urine. J Biol Chem. 1921 Jun;47(1):5-9.
34. Hedge JE, Hofreiter BT. In: Whistler RL, Miller JNB, editors. Carbohydrate chemistry. 17th Ed. New York: Academic Press; c1962. p. 163-201.
35. Soni A, Sosa S. Phytochemical analysis and free radical scavenging potential of herbal and medicinal plant extracts. J Pharmacogn Phytochem. 2013 Jan;2(4):22-29.
36. Siddique AN, Mujeeb M, Najmi KA, Akram M. Evaluation of antioxidant activity, quantitative estimation of phenols and flavonoids in different parts of Aegle marmelos. Afr J Plant Sci. 2010 Jan;4(1):1-5.
37. Bogaki T, Mitani K, Oura Y, Ozeki K. Effects of ethyl-α-D-glucoside on human dermal fibroblasts. Biosci Biotechnol Biochem. 2017 Sep;81(9):1706-1711.
38. Kar P, Dey P, Misra AK, Chaudhuri TK, Sen A. Phytometabolomic fingerprinting of selected actinorhizal fruits popularly consumed in North-East India. Symbiosis. 2016 May;70(1):159-168.
39. Mujeeb F, Bajpai P, Pathak N. Phytochemical evaluation, antimicrobial activity, and determination of bioactive components from leaves of Aegle marmelos. Biomed Res Int. 2014 May;10:497606.
40. Handique P, Deka CD. Methodology of rice beer preparation by some ethnic communities residing in Sivasagar District of Assam, India: A survey. Int J Multidiscip Res Dev. 2016 Jan;3(1):337-340.
41. Coe FG, Parikh DM, Johnson CA, Anderson GJ. The good and the bad: Alkaloid screening and brine shrimp bioassays of aqueous extracts of 31 medicinal plants of eastern Nicaragua. Pharm Biol. 2011 Jan;50(3):384-392.
42. Samaniego-Sánchez C, Marín-García G, Quesada-Granados JJ. A new fermented beverage from sugarcane (*Saccharum officinarum* L.) molasses: Analysis of physicochemical properties, antioxidant capacity, and comparison with other industrial alcohol products. LWT - Food Sci Technol. 2020 Apr;128:109-505.
43. Chakrabarty J, Sharma GD, Tamang JP. Substrate Utilisation in Traditional Fermentation Technology Practiced by Tribes of North Cachar Hills District of Assam. Assam Univ J Sci Technol Biol Sci. 2010 Sep;4(1):66-72.
44. Nono NR, Nzowa KL, Barboni L, Tapondjou AL. *Drymaria cordata* (Linn.) Wild (Caryophyllaceae): Ethnobotany, pharmacology and phytochemistry. Adv Biol Chem. 2014 Apr;4:160-7.

45. Chetia J, Borgohain T. Fermented alcoholic beverages of North-East India - A review. Int J Adv Sci Technol. 2020;29:9005-9014.
46. Joseph BS, Kumbhare PH, Kale MC. Preliminary phytochemical screening of selected medicinal plants. Int Res J Sci Eng. 2013;1(2):55-62.
47. Barua CC, Roy JD, Buragohain B, Barua AG, Borah P, *et al*. The anxiolytic effect of hydro-ethanolic extract of *Drymaria cordata* L. Willd. Indian J Exp Biol. 2009 Dec;47(12):969-973.
48. Ganesh P, Kumar RS, Saranraj P. Phytochemical analysis and antibacterial activity of Pepper (*Piper longum* L.) against some human pathogens. Cent Eur J Exp Biol. 2014 Jan;3(2):36-41.
49. Singh A, Lal UR, Mukhtarn HM, Singh PS, Shah G, *et al*. Phytochemical profile of sugarcane and its potential health aspects. Pharmacogn Rev. 2018 Jun;9(17):45-54.
50. Zhu LJ, Liu QQ, Wilson JD, Gu MH, Shi YC. Digestibility and physicochemical properties of rice (*Oryza sativa* L.) flours and starches differing in amylose content. Carbohydr Polym. 2011 Oct;86(4):1751-1759.
51. Bakht J, Noor N, Iqbal A, Shafi M. Antimicrobial activity of different solvent extracted samples from the leaves and fruits of *Capsicum annuum*. Pak J Pharm Sci. 2020 Jan;33(1):27-32.
52. Sannigrahi S, Parida S, Patro VJ, Mishra US, Pathak A. Antioxidant and anti-inflammatory potential of *Pterospermum acerifolium*. Int J Pharm Sci Rev Res. 2010 May;2(1):1-5.
53. Sharma HP, Basri F, Baraik B, Pathak C, Singh S. Pharmacological profiles of ethnomedicinal plant: *Plumbago zeylanica* L. - A review. Int J Pharm Sci Rev Res. 2014 Jan;24(1):157-163.
54. Patra S, Bhattacharya S, Bala A, Haldar PK. Antidiabetic effect of *Drymaria cordata* leaf against streptozotocin–nicotinamide-induced diabetic albino rats. J Adv Pharm Technol Res. 2020 Mar;11(1):44-52.
55. Bhuyan B, Baishya K. Ethnomedicinal values of various plants used in the preparation of traditional rice beer by different tribes of Assam. Drug Invent Today. 2013 Dec;5(4):335-341.
56. Nono NR, Nzowa KL, Barboni L, Tapondjou AL. *Drymaria cordata* (Linn.) Willd (Caryophyllaceae): Ethnobotany, pharmacology and phytochemistry. Adv Biol Chem. 2014 Apr;4:160-167.
57. Tiwari SC, Mahanta D. Ethnological observations on fermented food products of certain tribes of Arunachal Pradesh. Indian J Tradit Knowl. 2007 Jan;6(1):106-110.
58. Casida E. Industrial microbiology. New Delhi: New Age; c2005. p. 258-9.
59. Stanbury PF, Whitaker A, Hall SJ. Principles of fermentation technology. New Delhi: Aditya Books; c1997. p. 1.
60. Angmo K, Bhalla TC. Preparation of Phabs - An indigenous starter culture for production of traditional alcoholic beverage, Chhang, in Ladakh. Indian J Tradit Knowl. 2014 Apr;13:347-351.
61. Morita H, Takeya K, Itokawa H. A novel condensed tropone-isoquinoline alkaloid, pareitropone, from *Cissampelos pareira*. Bioorg Med Chem Lett. 1995 Mar;5:591-595.
62. Alam AM, Subhan N, Abdul AM, Alam SM, Sarder M, *et al*. Antinociceptive and anti-inflammatory properties of *Ruellia tuberosa*. Pharm Biol. 2009 Mar;47:209-214.
63. Kumar K. Notable pertinence of *Lygodium flexuosum* (L.) Sw. In: Singh JN, Singh GG, editors. Tribal medicine of India: An ethnopharmacognostical investigation. Houston: Sci Tech Publishing LLC. 2002;1:315-23.
64. Lans C. Ethnomedicines used in Trinidad and Tobago for reproductive problems. J Ethnobiol Ethnomed. 2007 Mar;3:1-12.
65. Panda SK, Rout SD, Mishra N, Panda T. Phytotherapy and traditional knowledge of tribal communities of Mayurbhanj district, Orissa, India. J Pharmacogn Phytother. 2011 Aug;3(7):101-113.
66. Thatoi HN, Panda SK, Rath SK, Dutta SK. Antimicrobial activity and ethnomedicinal uses of some medicinal plants from Similipal Biosphere Reserve, Orissa. Asian J Plant Sci. 2008 Mar;7(3):260-267.
67. Acharya N, Acharya S, Shah U, Shah R, Hingorani L. A comprehensive analysis of *Symplocos racemosa* Roxb.: Traditional uses, botany, phytochemistry, and pharmacological activities. J Ethnopharmacol. 2016 Apr;18:236-251.
68. Ramchander PJ, Middha A. Recent advances on *Senna* as a laxative: A comprehensive review. J Pharmacogn Phytochem. 2017 Mar;6(2):349-353.