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Ethnobotanical perspectives of *Bakhar*: an indigenous starter culture used to prepare traditionally fermented rice beverage in rural West Bengal, India

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Abstract

Haria, a fermented rice beverage, is commonly consumed as a traditional drink by the tribal people of rural West Bengal. This beverage is prepared by fermenting steamed rice with the starter culture tablets, known as *Bakhar*. It is known that some plant parts are added during *Bakhar* preparation that confer certain ethnomedicinal properties to the beverage as well as to *Bakhar* itself. An ethnobotanical survey was conducted that allowed documenting the traditional knowledge regarding this ethnic beverage preparation and it reveals that 10 plant species and one lichen species are used by the *Santal* tribe to prepare the *Bakhar*. Among them, roots of *Kedar*, *Chaoli*, rhizome of *Bach*, and bark of *Lodh* plants are essential, while other plant parts are used due to their specific taste, flavor, and therapeutic properties. But nowadays little or no plant additives are used during commercial *Haria* preparation for cost-effectiveness. Homemade and commercially produced *Haria* were investigated for their nutritional quality which revealed that homemade beverage contains more bioactive compounds, such as ascorbic acid (15.40 mg/100 ml) and flavonoids (36.67 mg/100 ml), which contribute toward the antioxidant property of the beverage. This current study documents the important medicinal plants used in the starter culture, the detailed process of *Bakhar* and *Haria* preparation, and the nutritional quality of *Haria* highlighting its ethnomedicinal properties.

Keywords: Food culture, Cultural heritage, Ethnomedicine, Starter culture, Beverage

Introduction

All over the world, distinct food practice is deeply associated with particular cultural community. In India, hundreds of different communities are there with their unique food habits. Among them, various tribal communities are flourishing in different states of eastern India. Tribal people are rich in their distinct ethnic cultures, lifestyle, and food habit. Particularly their traditional food and drinks are unique in such a way that they have a significant influence of that particular region [1].

In West Bengal, tribes (*Adivasis*) like *Santal*, *Munda*, *Oraon*, *Bhumij*, *Lodha*, *Mahali*, *Sabar*, etc., reside mainly in the western lateritic regions of Purulia, Bankura, Birbhum, Paschim Medinipur and Jhargram districts. Among them, *Santals* are one of the major tribal communities and constitute more than half (51.8%) of the total tribal population in this state.

In this entire tribal heartland, people consume *Haria* (*Handia*) or fermented rice wine as a traditional beverage. The term *Haria* is derived from *Hari*, the large round-bottom earthen pot in which the beverage is fermented. This alcoholic, milky white beverage is made from unpolished glutinous rice, fermented by some starter culture tablets (*Bakhar*) in sterilized earthen pots

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[2]. This ethnic drink occupies an important socioeconomic position, as tribal ladies prepare the beverage at home and sell it in weekly village markets (*Hat*). Along with the beverage, resources for the preparation of the beverage *Haria* as well as *Bakhar* tablets are also sold in those *Hats*. *Haria* also holds a deep cultural significance in the tribal communities as they offer it in certain ceremonies, festivities and sacred rituals [3]. However, consumption of the beverage is common among all age groups and it is not considered unhealthy among the *Santal* tribe. A little amount of *Haria* is also given to newborn infants. Apart from this study, there are some other reports that such fermented rice beverages act as an immediate remedy to treat indigestion, jaundice, cholera, and some other ailments such as sleep disorder, urinary issues, and for expelling worms [3–5]. According to the tribal people, *Haria* has some cooling properties that can prevent sunstrokes on harsh days of scorching summer.

The starter culture used to prepare the fermented beverage is known as *Bakhar* tablets. Such starter tablets act as the source of fermentative microorganisms that are yeasts and certain bacteria [6]. However, some particular plant parts are also added during *Bakhar* preparation. The starter is unique in such a way that along with its fermentative property it also possesses certain therapeutic characteristics [7]. Moreover, the ingredients used to prepare the starter culture tablets determine the aroma and quality of the beverage. According to the tribal people, the use of certain medicinally important plant parts in the preparation of *Bakhar* is the main reason behind its medicinal attributes that also enrich the beverage [5]. But due to the commercialization of this beverage, very little or no plant parts are added to the *Bakhar* for cost-effectiveness. According to the *Santal* people, commercially produced *Haria* is devoid of any therapeutic potentiality and also more intoxicating.

Keeping this in view, an effort has been made to study this age-old traditional practice of *Bakhar* and *Haria* preparation considering their ethnomedicinal attributes. The article emphasizes the ethnobotanical study to identify the plant ingredients and make detailed documentation of *Bakhar* and *Haria* preparation, and biochemical characterization of the beverage in terms of its nutritional quality. Such a study may help to protect the rich heritage of this food culture and can promote this ethnic beverage that can be economically helpful to the tribal people.

Methodology

Study area

The western lateritic (*Rarh*) zone of West Bengal (Fig. 1) is present in the east of the *Chota Nagpur* plateau where a

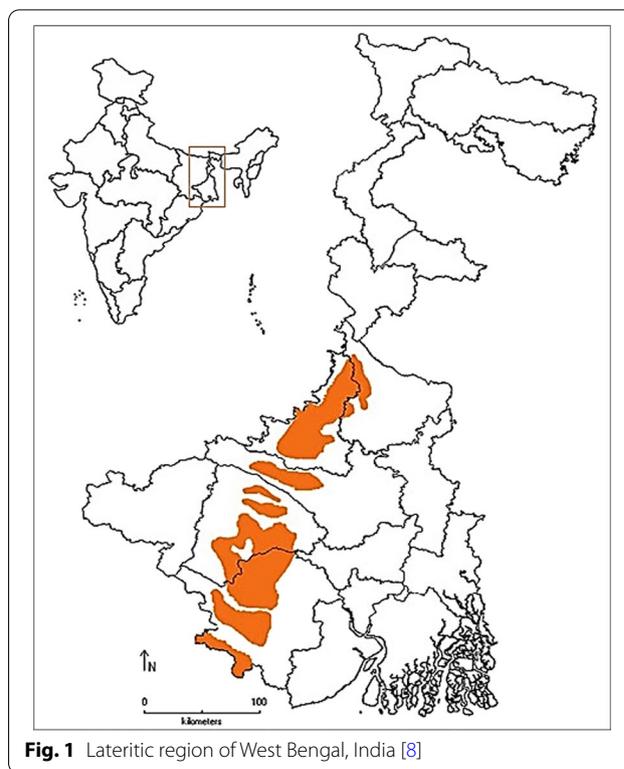


Fig. 1 Lateritic region of West Bengal, India [8]

vast group of tribal people flourished from ancient times [8]. According to the Census 2011, the tribal population of this state is about 5.8% of the total population and a higher concentration is seen in the northern and southwestern lateritic regions of West Bengal. This lateritic zone is predominantly semiarid, as summer temperature reaches up to 45 °C and in winter it drops below 15 °C. Monsoon months are comparatively pleasant with an average annual rainfall of 1400 mm. The predominant dry hot climate of this region leads to patches of subtropical dry deciduous forests [9]. Many tribal villages are located near the patches of these *Sal* (*Shorea robusta* Gaertn. f.; Dipterocarpaceae) forests that also host diverse life forms and provide food and shelter to these tribal communities. However, a vast majority of the population depends on agriculture and rice is one of the major crops. Therefore, rice-based food and beverages are a common delicacy in these tribal communities.

Research design and data collection

In the remote villages of West Bengal, weekly markets (*Hat*) are the center of life and livelihood. In those village *Hats*, selling and consumption of *Haria* are common among the tribal people. Along with the beverage, different ingredients of *Bakhar* such as dried plant parts, rice flour, ground plant powder, and ready-to-use *Bakhar* tablets are also sold there (See Fig. 2). An ethnobotanical



Fig. 2 *Bakhar* and its ingredients in a village market

survey was carried out to record the plant species used in *Bakhar* and the detailed process of *Bakhar* and *Haria* preparation. A field survey was conducted at the remote *Santal* village markets of the Bankura district through observations, semi-structured interviews, and some open-ended questionnaires [10]. Explorations were done in summer as production and consumption of *Haria* are relatively high during hot summer days. A total of 220 tribal people participated in the study, among them only 90 tribal people (70 Men and 20 women) including 30 producers, 20 sellers, and 40 consumers, provided information for data collection.

With prior informed consent (PIC), detailed documentation was carried out regarding (i) the procedure of *Bakhar* preparation, (ii) different plant parts used in *Bakhar*, (iii) their vernacular names and mode of application, and (iv) use of the starter tablets in terms of preparing the beverage, as well as its therapeutic uses [12]. To improve the accuracy of information, cross-verifications have been carried out among people of different villages through informal interviews and group discussions. During data collection, observations were made and the comments of responders as well as other people were noted.

Study and collection of plant parts used in *Bakhar*

Tribal people associated with *Bakhar* preparation were interacted to gather information regarding the usage of different plant parts in the starter culture. People were informed about the purpose of the study and

requested to share their knowledge regarding the usage of different plant ingredients and methods of *Bakhar* preparation. The process of *Bakhar* preparation was observed through personal visits and precise information was ensured through cross-checking. However, the exact proportion of different plant parts added during starter culture preparation is still elusive, because there is no standard regarding their usage. The composition of different plant parts varies greatly among different tribal groups and also depends on seasonal variation and availability of surrounding plant wealth. Moreover, the general process of starter culture preparation is almost similar among different tribal communities [11, 12]. Usually, the plant parts are collected from adjoining forests, but these days ingredients of *Bakhar* preparation including plant powders are purchased from local village markets. Plant samples were recorded and collected from the sellers for laboratory investigations in The Department of Botany, Visva-Bharati, Santiniketan.

Composition of *Haria*

Two *Haria* samples were collected in aseptic condition, and their proximate and biochemical characteristics were analyzed. Both of them were fermented in the same condition, and the fermented gruel was diluted equally with the same amount of water. But one *Haria* sample was fermented with such a type of *Bakhar*, which did not contain any plant ingredients (Sample-A), whereas another sample was fermented with *Bakhar*, which was fortified with plant ingredients (Sample-B). Total titratable acidity of both samples was determined by titrating them against 0.1 N NaOH to the phenolphthalein endpoint (0.1% w/v in 95% ethanol) following the standard method and expressed as % lactic acid [13]. The alcohol content was determined using the dichromate oxidation method and expressed as % V/V [14]. pH of the *Haria* samples was determined using a digital pH meter (Systronics, system 361, India). *Haria* samples were subjected to proximate analysis, and the moisture content, total carbohydrate, crude protein, and fat were determined following standard methods and expressed as % V/V [14]. The content of an important water-soluble vitamin, ascorbic acid, was measured using 2,6-dichlorophenol indophenol dye [15].

Polyphenols are an important group of compounds naturally present in plants, and these act as the major source of dietary antioxidants. A comparative study regarding the polyphenol content of both *Haria* samples was performed. The total phenol content was measured using Folin–Ciocalteu reagent, whereas flavonoid content was estimated using the aluminum chloride method and expressed as mg/100 ml [16]. Tannins are another group of complex polyphenols present in many plant-based foods. Total tannin content was also determined

using Folin–Ciocalteu method with slight modification [16]. The antioxidant property of both *Haria* samples was tested using DPPH radical assay and expressed as % RSA. The calorific value of *Haria* samples was calculated using protein, fat, carbohydrate, and alcohol contents, after multiplying the values with factors of 4, 9, 4, and 7, respectively, and all four multiplied values were added together to get the energy value of Kcal/100 g dry matter [13]. All individual biochemical experiments were done in triplicate ($N=3$) and results were expressed in mean \pm SD and experimental data were summarized using Excel 2016 software.

Results and discussion

Traditional beverage preparation by fermenting rice is a common practice of many tribes of northeast India. Table 1 enlists several popular fermented rice beverages prepared by different tribal communities residing in the states of northeast India. Production and consumption of such type of beverage (*Haria*) are also common among the *Santal* tribe of Bankura district, West Bengal. Previously some articles have been published regarding this traditional beverage [3, 23, 38]; but the plant additives used in the starter culture (*Bakhar*) are different among various tribal communities [18]. It has been observed that some plant parts are essential ingredients of *Bakhar*, whereas others are added depending on their availability as well as due to their therapeutic and organoleptic properties. Here, findings of the survey have been discussed emphasizing the ingredients of *Bakhar*, detailed process of its preparation, ethnobotanical status of *Bakhar*, traditional rice fermentation, and nutritional quality assessment of this ethnic beverage.

Ingredients of *Bakhar*

To begin with, rice flour and plant powder are the two main ingredients of *Bakhar*. Nowadays *Santal* people prefer *Lal Swarna* (Mtu 7029) rice variety, but according to some elderly producers in the near past local rice varieties like *Danarguri*, *Bhutmuri*, *Masuri*, *Rupsal*, *Kelesh*, *Tulsibhog*, *Patnai*, etc., were used to prepare *Bakhar* and *Haria*. Unpolished and parboiled rice is soaked in water and pounded with *Dheki* (wooden mortar) by tribal ladies to make a fine powder. Plant parts are usually collected from local forests, washed with clean water, and dried under sunlight. After drying, those are also ground to make powder. During the survey, it was also observed that dried plant powder and ready-to-use starter tablets (Fig. 2) were also sold in village markets by *Bakhar* sellers.

The survey revealed that different parts of 10 plant species and one lichen are used by the *Santal* tribe in *Bakhar* preparation and these belong to 11 different families. The plant species and their different parts used for this purpose along with the local names, family, and their therapeutic uses in traditional medicine are enlisted in Table 2. According to their habit, they are categorized into herbs (4), shrubs (2), climbers (3), trees (1), and one lichen species. It has been observed that among different plant parts root, fruit, seeds, leaf, bark, rhizome, and a lichen are also added as ingredients.

Interestingly among the 10 plant species, roots of *Asparagus racemosus* Willd. (Asparagaceae), *Acorus calamus* L. (Acoraceae), *Ruellia tuberosa* L. (Acanthaceae), and bark of *Symplocos racemosa* Roxb. (Symplocaceae) are essentially used to prepare *Bakhar*. Besides, dried fruits of *Piper longum* L. (Piperaceae), roots of

Table 1 Rice-based fermented beverages of India

Location	Tribe	Starter culture	Beverage	References
Assam	Bodo, Ahom, Karbi, Mising, Deori, Bodo, Rabha, Dimasa, Ahom, Karbi,	Humao, Amao, Ankur, Apop, Thap, Vekur pitha,	Judima, Jou, Jou bishi, Apong, Hor-arak, Xaj pani, Sujen	[6, 11, 17–20]
Arunachal Pradesh	Noctre, Adi-galo	Bichhi, Apop, Ipoh	Jumin, Apong, Opo	[1, 18, 22]
Odisha	Oraon, Munda	Bakhar, Ranu	Handia	[3, 23]
West Bengal	Santal, Oraon, Munda	Bakhar, Ranu dabai	Haria, Jhara	[7, 24, 25]
Himachal Pradesh	Pangwala, Gaddi	Dhehli	Sura	[26]
Uttarakhand	Bhotiya	Balma	Jaan, Chhang	[21, 27]
Meghalaya	Garos, Bodos, Hajongs, Pnars	Wanti, Thiat	Bitchi/Chubitchi, Kiad	[4, 28, 29]
Sikkim	Lepcha, Bhutia	Marcha	Chhang, Jnnar	[13, 30]
Nagaland	Angami, Dimasa	Tokai	Zutho	[18, 31]
Tripura	Kalai, Debbarma, Molsom	Hamei, Chuwak	Atingba, Yu, Beleb	[32, 33]
Manipur	Meitei, Loi	Hamei	Yu	[34]
Jharkhand	Ho	Ranu	Handia	[35]
Chhattisgarh	Gond, Kanwar, Pando, Majhwar	Ranu goti	Handia	[36]
Mizoram	Mizo	Dawdim	Zuphang, Zupui	[37]

Table 2 Plant parts used in *Bakhar* preparation and their therapeutic uses in traditional folk medicine

Scientific names and families	Local names	Parts used	Habit	Traditional uses
<i>Asparagus racemosus</i> Willd. (Asparagaceae)	<i>Kedar</i>	Root	Climber	Anti-aging, nervous disorder, bronchitis, liver diseases, dyspepsia [39, 50]
<i>Acorus calamus</i> L. (Acoraceae)	<i>Bach</i>	Rhizome	Herb	Sedative, diarrhea, depression, indigestion, fever, flatulence, cramps [40, 51]
<i>Ruellia tuberosa</i> L. (Acanthaceae)	<i>Chaoli</i>	Root	Herb	Flu, asthma, high blood pressure, eczema, bronchitis [41, 52]
<i>Symplocos racemosa</i> Roxb. (Symplocaceae)	<i>Lodhchal</i>	Bark	Tree	Liver and bowel complaints, gonorrhoea, tumors, skin diseases [42, 53]
<i>Piper longum</i> L. (Piperaceae)	<i>Pipul</i>	Fruit	Shrub	Chronic bronchitis, asthma, chronic malaria, cough, respiratory infection [43, 54]
<i>Hemidesmus indicus</i> R. Br. (Apocynaceae)	<i>Anantamul</i>	Root	Shrub	Rheumatism, impotence, urinary tract and skin infections [44, 55]
<i>Cassia senna</i> L. (Leguminosae)	<i>Sonapata</i>	Leaf	Shrub	Irritable bowel syndrome, splenic enlargements, Jaundice, hemorrhoids [45, 56]
<i>Polygala crotalarioides</i> Buch.-Ham. (Polygalaceae)	<i>Nilkanth</i>	Root	Herb	Cough and cold, fever, pulmonary catarrh [46]
<i>Ocimum basilicum</i> L. (Lamiaceae)	<i>Durlabha</i>	Seed	Herb	Headache, cough, constipation, warts, worms [47, 57]
<i>Rubia cordifolia</i> L. (Rubiaceae)	<i>Manjistha</i>	Root	Climber	Arthritis, acne, leucorrhoea, pharyngitis, intermittent fever, Jaundice [48]
<i>Parmelia perlata</i> (Huds.) Ach. (Parmeliaceae)	<i>Shailaj</i>	Whole plant	Thallus	Kidney stone, leprosy, seminal weakness, toothache, boils, calculi [49]

Hemidesmus indicus R. Br. (Apocynaceae), leaves of *Cassia senna* L. (Leguminosae), roots of *Polygala crotalarioides* Buch.-Ham. (Polygalaceae), and seeds of *Ocimum basilicum* L. (Lamiaceae) are used occasionally, as they are added for specific therapeutic purposes. However, roots of *Rubia cordifolia* L. (Rubiaceae) and a lichen, *Parmelia perlata* (Huds.) Ach. (Parmeliaceae), are only added in this preparation for qualitative improvement of *Haria*.

Some producers and sellers informed that almost 40 plant species were previously used to prepare *Bakhar*, while only 11 species are used at present, and among them only 4 are used regularly. There are reports that medicinal plants such as *Asparagus racemosus* [2, 20], *Ruellia tuberosa* [24], *Polygala crotalarioides* [2], and *Hemidesmus indicus* [36] are also used to prepare such starter culture by other tribal communities.

Preparation of *Bakhar*

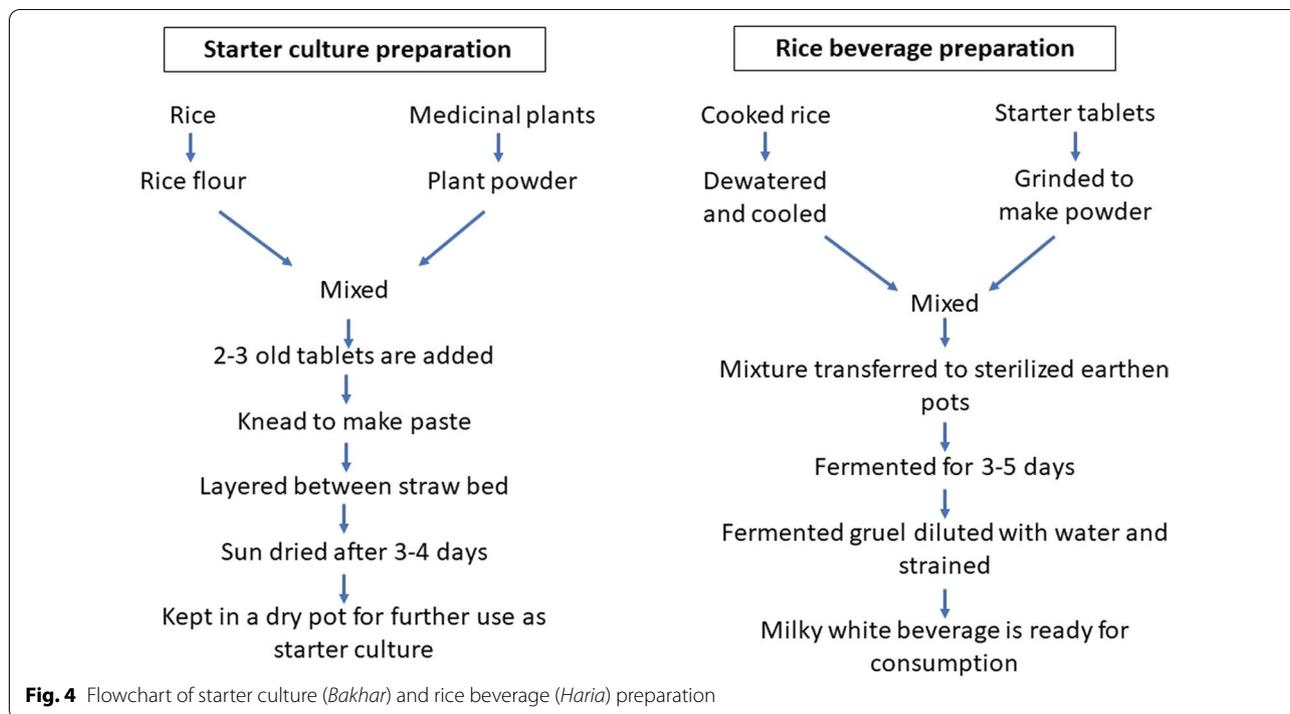
During survey, the detailed process of *Bakhar* preparation was documented. Main ingredient of *Bakhar* is par-boiled rice powder. Besides, dried plant parts are ground and blended to form a fine powder. An equal amount of plant powder is put together with rice flour. Then, 4–5 pieces of old *Bakhar* tablets are crushed and added with almost 1 kg of rice flour. Water is sprinkled on the rice flour mixture to knead it properly. Then, small balls of 2–5 cm diameter are prepared from the paste and layered between rice straws or clean mats prepared from leaves of *Khejur-Phoenix sylvestris* (L.) Roxb. (Arecaceae) and kept within a dry and dark room (see Fig. 3). After 3–5 days



Fig. 3 Freshly prepared *Bakhar* tablets layered on straw bed

of maturation (incubation period), depending on the seasonal temperature *Bakhar* tablets become ready for use. After drying under sunlight, these are stored in a clean and dry wooden container. The entire process of *Bakhar* preparation has been summarized and presented in the flowchart (see Fig. 4).

Generally, *Bakhar* tablets are round in shape and rough in texture, and light gray or white in appearance (see Fig. 5). Rice flour used in this preparation acts as a substrate for the fermentative yeasts and other microorganisms that are inoculated from the previously prepared *Bakhar* samples. As old inoculum is mixed with the rice flour, it provides the source of starch and other micronutrients and is utilized for growth and subsequent increase in microbial population during the incubation period. Some sources claimed that apart from the medicinal properties, those plant parts are also added to inhibit the growth of certain unwanted microorganisms [59].



Ethnobotany of *Bakhar*

In the present survey, primary respondents of the interviews were producers and sellers of *Bakhar* and *Haria*, while consumers were mostly ignorant about the plant ingredients. *Bakhar* producers usually collect these plants from local forests in autumn, but plant like *Manjistha* (*Rubia cordifolia*) is not available in such local forests, so they purchase it from sellers. They also mentioned that the lichen (*Parmelia perlata*) is usually collected from forests of hilly patches.

According to most of the producers, *Bakhar* is not only a simple starter to ferment the rice for *Haria* preparation, and it has very unique therapeutic property, also traditionally used by tribal healers to treat some ailments like amoebiasis, jaundice, gastrointestinal disorders, skin infections, etc. In such cases, tribal people use *Bakhar* tablets as a remedy by soaking 1–2 *Bakhar* tablets in lukewarm water overnight and early in the morning, and

the filtered water is administered orally. In case of joint pain, mumps, and certain skin infections, the paste of *Bakhar* is directly applied on the affected area. *Santali* people also use *Bakhar* with animal feed to treat some ailments of cattle such as cold, fever, diarrhea, poisoning, and to increase milk production.

All plants used in *Bakhar* have immense medicinal property, and there are several reports of their use in traditional medicine. The root of *Kedar* (*Asparagus racemosus*) is an important ingredient of *Bakhar*. It is a climber plant famous for its immense ethnomedicinal properties and is mainly used against gastrointestinal disorders, dyspepsia, and for its galactagogue effects [39, 50]. The rhizome of *Bach* (*Acorus calamus*) is known to treat fever, indigestion, kidney and liver disorders, depression and also acts as a mild sedative. [40, 51]. Root of *Chaoli* (*Ruellia tuberosa*) is traditionally used in case of bronchitis, asthma, flu and is also known for analgesic and antihypertensive properties [41, 52]. Another important ingredient, the bark of *Lodh* (*Symplocos racemosa*) is useful to cure liver complaints, tumors, gonorrhoea, and skin disorders [42, 53]. The spike fruit of *Pipul* (*Piper longum*), a flowering vine, is well known for its use in traditional medicine and also in Ayurveda. It is extensively used to treat chronic bronchitis, asthma, chronic malaria, cough, respiratory infections, etc. [43, 54]. The root of *Anantamul* (*Hemidesmus indicus*) is used in traditional medicine in case of rheumatism, snakebite, diabetes, skin diseases,

leprosy, syphilis, and urinary disorders [44, 55]. The *Sonapata*, leaf of *Cassia senna*, is well known for its use against irritable bowel syndrome (IBS), spleen enlargement, jaundice, and ringworm infection and also acts as a good laxative agent [45, 56]. Another ingredient, the root of *Nilkanth* (*Polygala crotalarioides*) is used in traditional medicine against some ailments such as cough, cold, and fever [46]. Dry seeded inflorescence of *Ocimum basilicum*, known as *Durlabha*, is a common ingredient of some Indian desserts (*Falooda*, *sherbet*). It offers immense health benefits due to its antioxidant, analgesic, anti-inflammatory, and antimicrobial properties and is useful to treat ailments like headache, cough, constipation, ulcers, worms, warts, etc. [47, 57]. *Manjistha*, the dried roots of *Rubia cordifolia*, sometimes added as an ingredient in *Bakhar*, is an important plant known for its ethnomedicinal properties such as alexipharmic, anti-dysenteric, astringent, carminative, febrifuge, and tonic [58]. Paste of *Manjistha* root is also applied topically to cure skin diseases like eczema, dermatitis, skin ulcers, etc. [48]. Another interesting ingredient used in *Bakhar* preparation is *Parmelia perlata*, a foliose lichen commonly known as *Pathar ful* (Stone flower). According to tribal people, when added with *Bakhar*, the lichen provides a mild aroma to the beverage that makes it more commercially attractive. It is also used to treat kidney stones, leprosy, seminal weakness, toothache, boils, calculi, etc. [49].

However, during the survey, it is also documented that nowadays due to commercialization little or no plant powder is added to the starter culture. The survey also revealed that an absence of such medicinally important plant parts in starter culture makes the beverage more inebriating. But till now, when *Haria* is prepared for home usage on certain occasions, *Bakhar* tablets fortified with plant parts are used to prepare the beverage. Two types of *Bakhar* samples are indicated in Fig. 5, as sample 'A' does not contain any plant parts as an ingredient, whereas sample 'B' is fortified with plant parts.

The rice beverage

Usually, the traditional beverage *Haria* is prepared by the tribal ladies at home. Large earthen pots (*Hari*) are used as fermenters where cooked glutinous rice is fermented by yeasts and other microorganisms present in the starter culture. Before starting the process, earthen pots are sterilized by burning and smoking with rice straw. Freshly prepared steamed rice is cooled and mixed with *Bakhar* at around 10 tablets per kilogram of rice. The mixture is now put into the *Hari*, and water is added to just submerge it. The blend is now kept in those enclosed earthen pots for 3–4 days to ferment the rice. After proper fermentation, the fermented gruel is diluted with more

water and filtered with a clean piece of fabric. The milky white fermented fluid is served as the beverage. The summarized process of *Haria* preparation is described in Fig. 4.

This rice beverage is also used by the tribal people as an immediate remedy against constipation, kidney and liver disorders, urinary tract infection, Jaundice, etc. Some literature also reported such traditional uses of the rice beverage among the tribal communities of northeast India [18, 60, 61].

The taste and flavor of *Haria* certainly rely on the plant parts present in the starter culture, *Bakhar*. During the fermentation process, plant metabolites are released from *Bakhar* and mixed with the beverage and they provide its distinct flavor and medicinal properties. During the survey, it was noted that consumption of *Haria* is usually higher during summer because according to the tribal sellers and consumers the beverage has cooling properties that keep them active on scorching summer days.

Biochemical composition of *Haria*

Two *Haria* samples were collected; the commercially prepared one was fermented with *Bakhar* tablets that did not have any plant ingredients (Sample-A), whereas homemade sample was fermented with fortified *Bakhar*, containing roots of *Asparagus racemosus* Willd., *Acorus calamus* L., *Ruellia tuberosa* L. and bark of *Symplocos racemosa* Roxb. (Sample-B). Biochemical characteristics of both samples were examined to discriminate any difference in their nutritional quality due to the addition of plant parts in the starter culture tablets (see Table 3).

To begin with, almost similar proximate values were obtained for both *Haria* samples, but the alcohol content is higher in case sample-A, which is fermented with *Bakhar* without any plant parts. The biochemical composition is also mostly similar in both samples. As *Haria* is a rice-based alcoholic beverage, it contains a higher amount of carbohydrate; that is, 78–80% of the dry matter and alcohol content reaches up to 5–8%. Energy values of both *Haria* samples were calculated using Atwater systems, which employ a single energy value of each main nutritional group (carbohydrate, protein, fat); but here energy value of alcohol is also taken into consideration. The calorific value of Sample-A is 122.08 kcal/100 ml and for sample-B, that is slightly lower as 107.73 kcal/100 ml (Table 3). Ascorbic acid (vitamin C) is an important water-soluble vitamin and also a potent antioxidant agent. Sample-A does not show the presence of Vitamin C, but sample-B contains 1.54 ± 0.20 mg/100 ml.

Dietary polyphenols are important bioactive phytochemical groups as they are the most abundant sources of antioxidants present in plant-based foods and beverages

Table 3 Physiochemical composition of *Haria* samples

Parameters	Sample-A	Sample-B
<i>Proximate</i>		
Optical density	0.34 ± 0.04	0.31 ± 0.01
Total solids (%DM)	8.2 ± 0.20	9.1 ± 0.34
Total acidity (% lactic acid)	0.3 ± 0.01	0.46 ± 0.01
pH	4.5	4.3
Alcohol content (%)	8.7 ± 0.10	5.07 ± 0.25
Moisture content (%)	90.05 ± 0.01	90.5 ± 0.06
Ash value (% DM)	0.34 ± 0.05	0.42 ± 0.02
Carbohydrate (%)	78.15 ± 0.23	80.44 ± 0.56
Crude protein (%)	3.47 ± 0.07	4.61 ± 0.06
Fat (%)	0.3 ± 0.02	0.45 ± 0.02
Energy value (kcal/100 ml)	122.08	107.73
<i>Vitamin</i>		
Ascorbic acid (mg/100 ml)	0.0	1.54 ± 0.20
<i>Polyphenol (mg/100 ml)</i>		
Phenolics (GAE)	2.45 ± 0.08	8.42 ± 0.08
Flavonoids (QE)	11.27 ± 0.06	36.67 ± 0.15
Tannins (GAE)	0.46 ± 0.01	1.12 ± 0.02
<i>Antioxidant property</i>		
RSA (%)	42.8 ± 0.08	68.51 ± 0.05

Sample-A Fermented with *Bakhar* that does not contain any plant parts; *Sample-B* Fermented with *Bakhar*, that is fortified with plant parts; *DM* Dry matter; *GAE* Gallic acid equivalent; *QE*: Quercetin equivalent; *RSA* Radical scavenging activity; Values are in mean ± SD ($n = 3$)

[62]. They can be divided into four major groups like phenolic acids, flavonoids, stilbenes, and lignans. Total phenol and total flavonoid content of two *Haria* samples were determined, and results showed that a significantly higher amount is present in case of sample-B which is produced with fortified *Bakhar* than Sample-A. Tannins are a group of large polyphenolic biomolecules, containing sufficient hydroxyl and other reactive groups that can bind to many biomacromolecules. Apart from its astringent property, sometimes tannins act as anti-nutrients and impair the digestion process by interfering with mineral and protein absorption [63]. Thus, total tannin content of the two types of *Haria* samples was examined and the result showed higher tannin content in Sample-B than in sample-A. Ascorbic acid and dietary polyphenols such as flavonoids act as antioxidant agents, and thus, free radical scavenging activity of both samples was tested and Sample-A showed 42.8 ± 0.08% scavenging activity, whereas Sample-B showed 68.51 ± 0.05% activity. This comparative biochemical study of two *Haria* samples signifies the importance of added plant parts in *Bakhar*, as phytochemicals are leached out from *Bakhar* during rice fermentation and enrich the beverage. It can be summarized that if fortified *Bakhar* is used as the starter for rice fermentation to prepare *Haria*, it becomes

a carbohydrate-rich mildly alcoholic beverage, containing bioactive phytochemicals with antioxidant properties. But further research is needed to identify potential phytochemical compounds present in *Haria* to justify its traditional therapeutic claims beyond doubt.

Conclusion

From time immemorial, tribal people consume beverages prepared with traditionally fermented rice. Rice acts as a cheap source of carbohydrates in traditional fermentation. In remote tribal villages, this beverage is also used as an immediate remedy against certain gastrointestinal ailments such as diarrhea, colitis, and irritable bowel syndrome. It has very low alcohol content and provides some essential nutrients and also hydrates the body. However, along with the beverage the starter culture, *Bakhar*, also has immense ethnopharmacological benefits. It is not only used as a fermentation starter but the plant parts used in its preparation confer certain pharmacological attributes. Secondary metabolites from those plant parts are released during fermentation which contribute to its therapeutic nature. However, this study does not reveal any standardized parameter regarding the usage of plant parts in the starter culture. Further scientific study is needed to standardize its preparation and to explore its bioactive phytochemicals responsible for health benefits. Since the use of different plant parts in this preparation declines constantly, hence such an ethnobotanical study will preserve the knowledge regarding this formulation. In rural villages of West Bengal, the preparation and marketing of this traditional rice beverage is a primary source of income for many tribal families. It can be said that a small-scale cottage industry is running based on this traditional drink. We hope that more such scientific studies on this beverage and its starter culture, emphasizing its medicinal and nutritional values, will be helpful to popularize it.

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Sukanta K. Sen—Presently retired.

Author contributions

SKS and SM conceived the idea and designed and supervised the research work. SG performed the survey and laboratory work. SG and SM compiled data and prepared the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

All the material/data used are available in the manuscript.

Declarations**Competing interests**

The authors declare no competing interests.

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