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**A BRIEF HISTORY OF FERMENTED RICE-BASED BEVERAGES – FROM ANCIENT
TIMES TO TODAY**

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ABSTRACT

Rice is the staple food for many Asian countries like India. In the age-old times, it was a suitable substrate for beer fermentation. It was reported that many tribal communities from different parts of India use rice and additional ingredients for beer making process, which is a very ancient technology adopted by them. Without any scientific Knowledge, the processing of different fermented foods was embraced and traditionally transferred to the next generation which was scientifically analyzed by research groups. This compelled investigators to explore the technology that helps in the establishment of this age-old skill with science. The research found that the presence of yeasts and their secondary metabolites make this drink edible and health beneficial. Additional substrates like plant parts or storage time and containers make them different. This way fermented foods got importance to their preparation. Fermented foods were mainly meant for the storage of waste grains. Later, researchers reported that the biochemistry of *Saccharomyces* and non-saccharomyces groups of organisms contribute to their organoleptic properties and make them valuable in various ways. Rice-based fermented alcoholic drinks have a long shelf-life period. Fermented rice beverages are traditionally, scientifically attached to people from ancient times till today. The current scenario in the fermentation industry is looking for effective potent yeast which could help them in the preparation of fermented beverages with

unique flavour, aromas, and with probiotic nature. These requirements imply the search for wild yeast over a commercial one.

Keywords: fermentation, fermented foods, microbial diversity, secondary metabolites, substrate

INTRODUCTION

Fermentation, the oldest technology is used worldwide for food preservation by many communities. The presence of microbial consortia helps in biochemical modifications of the fermented food products which make them completely edible products by the addition of taste, aroma, shelf life, texture, and nutritional value to it [1]. In the world, different cultures adopt the preparation of fermented beverages as their cultural heritage many years ago. For the preservation of perishable foods, fermentation technology was mostly accepted by human civilization. In order to reduce the loss of fruits, seasonal fruits were mostly used for making beverages [2]. Rice is used as a staple cereal as well as a substrate for fermentation in Asia because of its availability [3]. In different places, rice-based alcoholic beverages are named differently, such as Lao-Chao in China, Sake in Japan, Chongju and Takju in Korea, Tapuy in Philippines, Brem Bali and Tape-Ketan in Indonesia, Khaomak in Thailand, Rou Nep Than in Vietnam and Tapai Pulul in Malaysia [4]. In India, the northeast region is known for its population diversity with varieties of ethnic and cultural backgrounds [5]. The

tribal communities of northeast India engage in cultivating varieties of rice predominantly. Therefore, the preparation and consumption of rice-based beverages are very common as their traditional practices [6]. For two-thirds of the Indian population, rice is the staple food, and India is placed as the second largest producer and consumer of rice in the world [7].

This review focuses on the preparation of different fermented foods and beverages in India. It also explains the importance and biochemistry of yeast in the preparation and improvement of organoleptic properties of beverages as a result of fermentation. It also discusses the health benefits and nutritional value of beverages. In brief, this review highlights the fermentation from the age-old technique to till date. It explains the beautiful journey of time when people didn't know about science to the time when they apprehend the science and technology behind it.

HISTORY OF ALCOHOLIC FERMENTED FOODS AND DRINKS

Fermentation originates from the Latin word "fermentum" which means "to boil". The

fermentation process is a product formation process by a mixture of microbes [8]. In Vedic times, Rigveda has information on fermentation techniques that were connected with the preparation of alcoholic beverages named soma juice. Sura was another fermented drink of wine or beer which was the result of the fermentation process of boiled rice/barley [9]. There were also many famous fermented drinks named medaka, Prasanna, and asava used during the post-Vedic period (600 BC to 100 CE). Spiced rice beer as medaka, spiced barley or wheat beer as Prasanna, and sugarcane beer as asava were popular drinks among the people. There were also many different new recipes formulated to prepare different kinds of fermented drinks. Many such new formulations were found in Rasopanisat. One of them was explained as bulbous plants' latex with grains of rice (Kodrava) and madana plant products combinedly made paste with whey from water buffalo and cow milk which was kept in a closed vessel. These vessels were kept in sun. From this, the acidic residue obtained was named kinva (yeast). Another such drink was named sukta – it was made up of treacle, honey, fermented rice, water, and whey. Mixed properly and kept in an earthen pot which was fermented on heaps of paddy for three nights during

summer. Another such drink was known as Kanjika – different parts of plants were added to boiled millet or barley or boiled rice [10]. The fermentation technique was adopted by local people for the preservation and preparation of different foods. But with a lack of knowledge about microbes, they did not understand accidentally the involvement of these microbes helping in food preparations. People had great knowledge and information about their locales which means the plants, animals, climate, and environment. Keeping these parameters in mind, they used to formulate the beverages and fermented food products. They had an immense idea about their ecosystem and techniques to manage plants and animals [11]. For the fermentation process, people used common utensils and ingredients which was available locally. It was reported that varieties of fermented products local people formulated depending upon the availability of meat, fish, cereals, vegetables, pulses, and milk from their areas. These foods were famous for their taste and smell and also for health benefits like caloric value, the shelf life of products, etc. [12]. In India, fermented foods are not only famous among low-income groups but also have a space in high-income groups. There is the traditional process of preparations of beverages which is

still done by specific tribes and castes in different parts of India. Some of the fermented foods are very delicious and are used to export. India is a diverse center for fermented food products. The regions which are considered hotspots of fermented beverages are South India, Himalayan India, East India, and North-East India [13].

SELECTED RICE-BASED INDIGENOUS BEVERAGES FROM DIFFERENT PARTS OF INDIA AND THEIR HEALTH BENEFITS

1. Sour rice

It is a type of fermented rice used by people of the eastern and northeastern regions. It has its local name, in Odisha as pakhala, Assam as Panta bhat, and in Bengal as poita bhat. Ingredients used for preparation are rice and water. The process starts with cooked rice. First, rice is cooked and cooled down to room temperature. A required amount of water is added to it and kept for fermentation overnight. The organisms associated with the process are *Lactobacillus bulgaricus*, *Lactobacillus casei*, *Pediococcus acidilactici*, *S. faecalis*, *Streptococcus thermophilus*, *Microbacterium flavum*, and *Saccharomyces sp.* It was reported that sour rice contains vitamin B complex, and vitamin K, 73.91 mg

iron/100 gm, 303 mg sodium/100gm, 839 mg potassium/100gm, and 850 mg calcium/100gm of sour rice. It is high in energy and rehydrating food especially taken in summer to avoid dehydration. Thus, the beverage prevents constipation as contains high fiber which controls bowel movement. It is also functioning as a probiotic by restoring healthy intestinal flora. Sour rice is such a health-beneficial beverage that prevents many gastrointestinal ailments like duodenal ulcers, infectious ulcerative colitis, Crohn's disease, irritable bowel syndrome, celiac disease, candida infection, etc. [14].

2. Sez

People of Himachal Pradesh prepare sez from starter culture balam. It is a very well-liked beverage prepared during the gala occasion. Cooked rice is taken in a sealed wooden or earthen container mixed with balam which is kept in a dark and cool place. Anaerobic fermentation results in the formation of semi-fermented rice. Semi-fermented rice is consumed by the communities. It was reported that the fermentation process is saccharolytic which is the reason for the bioconversion of starch to alcohol [12].

3. Haria

It is considered a staple food as well as revitalizing drink by many of the Indian tribes. Bakhar, a starter culture mixed with scorched rice is kept in an earthen pot. The fermentation process takes 3 to 5 days. After fermentation, the drink is diluted and sieved, which is served as haria. It was reported that numerous molds and yeasts are found to be highest on 2nd day of fermentation, and then the number deteriorated, but, on the other side, Lactic Acid Bacteria and *Bifidobacterium sp.* increased during the fermentation process. It is not only a festal drink but also conveyed its use as health benefits. The drink prevents gastrointestinal ailments like dysentery, diarrhea, amebiasis, acidity, and vomiting. The antioxidant property is also described in Haria [15].

4. *Apong*

Apong is prepared in northeastern states like Assam and Arunachal Pradesh. Cooked rice is taken for preparation and paddy husk, straw, and starter culture are added to it. This preparation is kept in an earthen pot for 20 days for fermentation to take place. The temperature is maintained at 30°C to 35°C. The fermented product is filtered to get apong which is brown in colour. It is stated that

apong prevents kidney stones. The scientific analysis reported *S. cerevisiae*, *Hanseniaspora sp.*, *Kloeckera sp.* *Pichia sp.*, and *Candida sp* organisms' involvement in this drink [16].

5. *Jou*

It is a conventional sociocultural drink of the Boro tribe of the northeastern region. It is prepared by using starter culture emao. Emao is mixed with air-dried cooked rice, chili, and charcoal, and kept in an earthen pot. After 3 to 5 days of the fermentation process, the drink is diluted, filtered, and consumed. It is a refreshing drink of Boro tribes that keep the body relaxed. The health benefits are also narrated as it prevents jaundice and urinary disorders [6].

6. *Judima*

Judima is a fermented rice beverage from northeast India. Starter cake humao is used for preparation. Air-dried boiled rice is mixed with humao and kept for 3 to 4 days of fermentation. It is transferred to the bamboo cone. After fermentation, pale to dark yellow coloured leachate judima is collected for a drink. The literature says that Judima has many health benefits like anti-inflammatory, antiallergic, antioxidant, antibacterial, antifungal, antispasmodic,

hepatoprotective, hypolipidemic, neuroprotective, hypotensive, antiaging, and antidiabetic potentialities [17].

7. *Zutho*

Naga people formulate Zutho fermented beverage. Cooled rice porridge is used for this purpose which is mixed with grist. It is kept in an earthen jar for 2-3 days of fermentation. After the fermentation period, zutho is ready to drink directly. Health benefits are reported as zutho is a booster of immunity, insulin-dependent diabetes can be controlled, appetite can be improved, cholesterol level can be controlled, wounds can be healed by the same, and infection can be prevented [18].

8. *Bhaati jannr*

It is a mild alcoholic sweet beverage of the Eastern Himalayas. To prepare this beverage, cooked air-dried glutaneous rice is used. It is mixed with starter powder marcha. The mixture is kept in a vessel at room temperature for 2 to 3 days. A thick paste of this mixture is made and consumed directly by people. It is also considered a staple food for Eastern Himalayas. It is reported that bhaati jannr is good for postnatal women for their recovery of physical strength [19].

9. *Rice jann*

Bhotiya tribal community of Uttaranchal State in Western Himalaya prepares rice jann using the natural resources found in high altitude regions. The boiled rice is cooled and the starter Balam is mixed with it for the preparation of the beverage. It is stored in an earthen airtight pot. The fermentation takes 6 to 10 months at room temperature. After the fermentation process is over, the beverage is diluted, filtered, and consumed by people. Research revealed that rice Jann is an energy drink, and refreshing drink, that also protects people against different health issues [20].

ROLE OF *Saccharomyces cerevisiae* IN FERMENTED BEVERAGES

Saccharomyces cerevisiae is a yeast that can utilize different carbon sources. Cereals, Sugar Cane, Molasses, Fruit, Agave, Whey, etc. are different raw material which is generally used for the beverage production process. Fermentable sugars present in these carbon sources are Maltose, Maltotriose, Sucrose, Fructose, and Glucose respectively. In the presence of *Saccharomyces cerevisiae*, these sugars are fermented into different beverages. After the maturation process during fermentation, the products are e.g., Beer, Wine, Cider, and Mead. The

distillation products in the fermentation process are Matured Spirits (e.g., Whisky, Cognac, Rum) and non-matured spirits. Again, non-matured spirits are differentiated into Non-Flavoured (e.g., Vodka, Grappa, Tsiporo) and flavored (e.g. Gin) products [21].

FERMENTATION BY YEAST

Yeasts are present in the sugar-rich environment. Grapes and different fruits are a natural habitat for them. Especially in the winemaking area, fruit surfaces, and yeasts make different communities. But considering niches and their conditions, like ripen or damaged stage, varieties of yeasts are reported. Grape must is a habitat for yeasts for having a suitable condition for their nourishment and growth like low pH, and high osmotic pressure but the presence of SO₂ is only an obstacle for them. Other factors also decide the presence of types of yeast species. The non-Saccharomyces group of yeasts adds flavour to beverages as they also produce different secondary metabolites. This group of yeasts depends upon different environmental factors for the production of secondary metabolites. In the case of wine, the quality of grape must, osmotic pressure, pH, presence of glucose and fructose, presence or absence of SO₂, temperature, the concentration of alcohol, and quantity of

nutrients present in the medium – factors decide the type and quantity of secondary metabolites production [22]. Along with secondary metabolites, the non-Saccharomyces group of yeasts also indulge in the conversion process. These groups of yeasts including *Debaryomyces*, *Hansenula*, *Candida*, *Pichia*, and *Kloeckera* have β -glucosidase activity. This enzyme makes non-volatile precursors present in beverages to produce volatile compounds. *Debaryomyces hansenii* has an intracellular enzyme β -glucosidase that is used during the process of fermentation which increases the concentration of monoterpenols in wine [23]. According to Louis Pasteur, wine fermentation is defined as the process of converting grape sugars to alcohol and CO₂ in the presence of yeast as the primary catalyst. Fermentation is reported from different parts of the world using food as raw material, a part of human culture. Wine is the oldest fermented product that still exists. Beer is another fermented product that is the most practiced alcoholic beverage and secured the third position of general beverages. It was used for nutrition, religious practices, and for treatment of diseases. Nowadays, there are different types of beer prepared by using methods of the brewing process as well as a mixture of ingredients.

The taste is developed by adding hops. The addition of hops for the preparation of beer also increases the shelf-life of beer by its lowering pH and antibacterial mechanism [24].

Fermentation is followed by yeast growth. So, nutrient transportation and assimilation in the cell are also part of the fermentation process. It will increase the biomass and biomass will help alcohol production. The preliminary target of the fermentation process is to provide nutrients to cells for their nourishment and growth. An increase in biomass is directly proportional to alcohol production. Maintaining redox balance and making enough ATP will help in ethanol production. But at the same time, controlled yeast biomass should be maintained to avoid less alcohol production. Therefore, fermentation is employed in continuous/semi-continuous fermentation, and/or immobilized yeast bioreactors. In different stages of the growth of yeasts, maximum sugar is utilized, and alcohol is produced by them in the exponential phase. It was found that growing yeast cells are more efficient in alcohol production than non-growing cells. It is approximately 33 times higher in growing yeast cells [25].

The uniqueness of yeast is that it can switch to respiration from fermentation. To utilize

sugar i.e., glucose, yeasts always take the fermentative route if glucose is present at a high concentration in the surrounding. It is known as the Crabtree effect. The Crabtree effect says that yeasts cannot be considered as a true facultative anaerobic organism, because a 1% presence of fermentable sugar in culture media makes them switch to anaerobic metabolism. Yeasts are capable to utilise sugar aerobically as well as anaerobically. The difference is aerobic respiration ends up with more energy than the anaerobic process. This anaerobic breakdown of sugar which produces less energy is known as fermentation. When sugar is taken up by the cell, it converts to pyruvate through a glycolytic pathway or EMP pathway (Embden-Meyerhof-Parnas). The sequential reactions that take place for conversion are termed glycolysis. But all glucose cannot be metabolized in the EMP pathway rather some of the sugar is metabolized using the hexose monophosphate pathway. When sugar is present in low concentration in the presence of oxygen, growing yeast cannot produce ethanol, or a very low amount of ethanol is produced. In this case, yeasts use sugar in the form of energy for its multiplication. On other hand, if oxygen concentration remains

low and glucose is more, ethanol is produced [25].

MICROBIAL DIVERSITY IN ALCOHOLIC FERMENTED BEVERAGES

Starch is the main component of rice. Microbes can grow easily on starch-containing cereal-based media. These microbes are either natural or spontaneous or added as a starter culture. As they grow, they secrete many metabolites which make their environment favourable to flourish and prevent pathogens to grow. Again, these microbes have nutritive as well as therapeutic values. Microbes that are commonly found in fermented foods are lactic acid bacteria (LAB), Lactobacilli, Bifidobacteria, yeasts, and molds [12].

Lactic acid bacteria are acid-tolerant, gram-positive bacteria. A group of bacteria that produces lactic acid during the fermentation of carbohydrates. They are good bacteria used for human health benefits. Lactic acid bacteria constitute a group of different bacteria namely *Aerococcus*, *Corynebacterium*, *Enterococcus*, *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Oenococcus*, *Pediococcus*, *Streptococcus*, *Tetragenococcus*, *Vagococcus*, and *Weissella*. Their products during fermentation add nutrient value to the foods.

They increase minerals, vitamins, and essential amino acid synthesis which can neutralize antinutrients, mycotoxins, and other endotoxins and increase food value. These groups of organisms also help in the organoleptic properties of food by adding taste, aroma, texture, consistency, and appearance. Other lactic acid-producing bacteria are *Lactobacillus* and *Bifidobacterium*. These are non-spore-forming gram-positive rods associated with the fermentation process. plant-derived polysaccharide and oligosaccharide complexes like dietary fibers, glycans, oligosaccharides, resistant starch, cellulose, hemicellulose, xylan, arabinofuran, arabinogalactan, pectins, and gums can be digested by the enzyme glycoside hydrolase which is produced by LAB group of organisms. These groups of organisms are also capable of yielding antimicrobial substances, glutamic acid, aspartic acid, vitamins, and many other bioactive metabolites. Much scientific kinds of research revealed that LAB is a probiotic. They are health-beneficial organisms. They can prevent diarrhea, establish health-beneficial bacteria in the gut region, have colon regularity, are helpful in lactose intolerance, help in reducing cholesterol, have immune stimulatory effects, and even

can prevent cancer. The yeasts present in this type of fermentation process are *Saccharomyces*, *Candida*, *Hansenula*, *Saccharomycopsis*, and molds like *Aspergillus*, *Rhizopus*, *Mucor*, and *Penicillium*. Yeasts also add taste, aroma, and texture to food products. Organoleptic properties are developed by producing a group of compounds such as glycosides, esters, fusel alcohols, acids, and other compounds from yeasts. Along with the above-mentioned compounds yeasts are also capable of producing ethanol which serves as energy and helps in preventing the growth of undesired organisms [26].

MICROBIAL TRANSFORMATION DURING FERMENTATION

There are four different types of fermentation processes known. They are alcoholic, lactic acid, acetic acid, and alkali fermentation. In the alcoholic fermentation process, ethanol is produced by yeast. Lactic acid fermentation is of two types – homofermentative and heterofermentative by Lactic acid bacteria. In fish and seeds, the alkali fermentation process is observed. In the case of rice, acidic and alcoholic fermentation or both was reported [15].

Rice fermentation starts with the pre-treatment process of grains. The pre-treatment process includes soaking, grinding,

and boiling rice. The pre-treatment process helps in the breakdown of complex structures into simple structure means from starch to simple sugars. In some cases, soaking is extended for the germination of rice grains by hydrolytic enzymes which break down starch to simple sugars by exo and endo-cleaving actions [15].

Rice when mixed with different pulses for fermentation, the batter is prepared. In this type of fermentation, CO₂ and other gases are released by microbes. This process makes the batter spongy. Fermentation requires proper time which gives food taste, aroma, texture, and appearance [27].

Rice consists of amylose which is a complex carbohydrate, difficult to digest by microorganisms. So, the first step of the rice beer fermentation process is to break down the complex compound through amylolytic enzymes. This action is done by amylolytic molds which are grown first to saccharify and liquify rice. α amylase converts starch into dextrins and glucoamylase hydrolyses dextrins into glucose. An anaerobic environment is set up by the decomposition of rice. Simplification of rice leads to the growth of LAB and Bifidobacterium along with lactic and acetic acid bacteria. Many hydrolytic enzymes as well as metabolites are produced by these bacteria. Then,

Saccharomyces cerevisiae, alcohol-producing yeast filled the food product with different vitamins and amino acids which add flavour and aroma to it. This simplification of compounds through different microbes in a step-wise process makes beverages assimilate rapidly in the gastrointestinal tract. It releases maximum energy. This is the reason behind the health benefits of beverages over solid and semisolid fermented food products [27].

SECONDARY METABOLITES DURING THE FERMENTATION PROCESS

During fermentation, primary products formed are ethanol and carbon dioxide, and secondary metabolites are also produced which are very low in concentration. These secondary metabolites are - higher alcohols, polyols, esters, organic acids, vicinal diketones, and aldehydes. These secondary metabolites play a very important role in imparting flavour to fermented beverages. Higher alcohols like Isoamyl alcohol, phenyl ethanol, and isopropanol add flavour and aroma to distilled spirit type of fermented beverage. Esters like ethyl acetate in beer and wine add fruity and floral aroma and flavour. In beer, secondary metabolite - Carbonyl compounds such as acetaldehyde can add grassy or green apple flavour which can be removed during the conditioning process.

Organic acids like succinic acid, citric acid, and acetic acid add sharpness to the fermented beverage. But the presence of lactic acid indicates the presence of bacteria which can spoil the beverage. Glycerol is a polyol that is produced during the osmotic stress of yeast as part of metabolism. It adds viscosity to wine. Diacetyl, Pentane-2,3-dione Diacetyl is also found as a secondary metabolite in beer fermentation which gives a rancid butter-like smell. But it can be reduced during beer conditioning. The presence of sulfur compounds adds flavour and aroma to beverages. Phenolic compounds impart off flavour, but 4-Vinylguaiacol is present in some beer styles. These produced secondary metabolites during the fermentation process affect the organoleptic properties of beverages. Secondary metabolites are not only the product of wild yeasts, rather different members of the *Saccharomyces* genus as well as a non-saccharomyces group also affect aroma and flavour. *Saccharomyces cerevisiae* is considered wild yeast which is the root cause or starts organism of fermentation. But the presence of bacteria in fermentation indicates contamination because their presence makes the quality of the beverage low which is mostly seen in beer. Because of bacterial contamination in beer,

the product spoils with off flavour, poor foam stability, and unstable life span. In spoiled beverage dominating bacteria is lactic acid bacteria and sometimes acetic acid bacteria [21].

BEVERAGE PRODUCTION FROM WILD YEAST OVER COMMERCIAL YEAST

Yeasts are found everywhere but they prefer to grow in sugar-rich environments. Fruits are the main source of sugars in plants. Nectars, flowers, fruits, decaying tissues, and tree saps make a home for wild yeasts. These attract a diverse group of yeasts to dwell on it. Reported yeasts were *Candida albicans*, *Debaryomyces hansenii*, *Kodamaea ohmeri*, *Rhodotorula mucilaginosa* from fruits like lemon, mango, and guava. The study reveals the presence of yeasts varieties in fruits and blossoms of apple, plum, and pear orchards. Yeasts are mixed in the process of fermentation by the addition of additional substrates like plant parts e.g. flowers, fruits, different plant parts, etc. [28].

Wild yeasts are the new trends of brewers. The importance to hunt their presence is to unearth the properties in it which could contribute to the potential of products. The resource of traditional yeasts is the environment [29]. However, in the case of mixed fermentations, many yeasts of the

microbial community are anonymous. But the knowledge of starter culture used for the preparation of beverages could give an idea of the presence of yeast in a mixed population. The properties of yeasts could be evaluated if the composition of the beverage is known. Piraine *et al.*, isolated non-conventional yeasts from flowers, fruits, leaves, and mixed-fermentation beers for their identification and characterization. They found that the yeasts were found to be probiotic in nature and also claim encouragement in the beer fermentation process [30]. One of the factors responsible for the quest for new yeast is the innovative charm of beer, therefore, diversity is essential. The leading yeast, *Saccharomyces cerevisiae*, is the primary and foremost requirement in the case of alcoholic beverages. At the present time, a very low number of strains are applied in beer production globally which is remarkably minimal. On the other hand, remembering yeast as a brewer's aroma contributor in beverages was influenced by the advent of expert brewing. This is another motivation to unveil the fermentation process in a new way. Novel strains are a new grace over the traditional yeast used in the fermentation process [31]. One of the novel yeasts reported by Nikulin *et al.*, *Saccharomyces*

paradoxus, was isolated from Northern Europe and North America from the environmental samples. *Saccharomyces paradoxus* was an occasionally found yeast related to fermentation. The relevance of non-conventional and local yeasts are the keen interest of brewers and research group in the establishment of novelty in beverages [32, 33].

CONCLUSION

In fermentation like alcoholic beverage production, strain development is employed for efficient yeasts to improve the process. Researchers aim to develop such kinds of yeasts which will satisfy the organoleptic properties of beverages as well as be potent for quality and quantity alcohol conversion, sugar utilization, etc. The most important factor for beverage production is yeast. Different types of yeasts harbor in fruits. their isolation and application could help reach out to a novel strain. Novel, local and non-conventional yeasts presently play a big role in the beer-making market for their contribution to the novel aroma, taste, and probiotic nature. It is also true that these organisms could be a source for new product development. This novelty of yeast strains could also contribute to the local economy if it is used with a suitable approach.

REFERENCES

- [1] Mangang K.C.S., Das A.J, Deka S.C, Comparative shelf life study of two different rice beers prepared using wild-type and established microbial starters, J. Inst. Brew, 123(4), 2017, 579–586
- [2] Buglass A. J. ed. Handbook of Alcoholic Beverages, Set: Technical, Analytical and Nutritional Aspects, John Wiley & Sons, 1, 2011.
- [3] Ministry of Agriculture and Cooperatives. Statistical information on Nepalese agriculture 2005/2006 (2062/2063). HMG, MOAC, Agriculture Business Promotion and Statistical Division, Sing Durbar, Kathmandu, Nepal.
- [4] Aidoo K.E., Rob N. M. J, Sarkar P. K, Occurrence and function of yeasts in Asian indigenous fermented foods, FEMS yeast research, 6(1), 2006, 30-39.
- [5] Pullaiah, T., Krishnamurthy, K.V, Bahadur, B. eds., Ethnobotany of India, 5-Volume Set. CRC Press, 2021.
- [6] Das A. J, Deka S. C, Fermented foods and beverages of the North-East India, Int. Food Res. J, 19, 2012, 377– 392.
- [7] Terefe N.S, Recent developments in fermentation technology: toward the next revolution in food production, Food Engineering Innovations Across the Food Supply Chain, 2022, 89-106.

- [8] Sekar S, Mariappan S, Usage of traditional fermented products by Indian rural folks and IPR, *Indian J Tradit Know*, 6, 2007, 111e20.
- [9] Roy M, Fermentation technology, New Delhi: The Indian National Science Academy, 1997, 437-447.
- [10] Chakrabarty J, Sharma G. D, Tamang J. P, Traditional technology and product characterization of some lesser-known ethnic fermented foods and beverages of north Cachar hills district of Assam, *Indian J Tradit Know*, 13, 2014,706e15.
- [11] Tamang J.P, Okumiya K, Kosaka Y, Cultural adaptation of the Himalayan ethnic foods with special reference to Sikkim, Arunachal Pradesh and Ladakh. *Himalayan Stud Monogr*, 11, 2010, 177e85.
- [12] Satish K. R, Kanmani P, Yuvaraj N, Paari K. A, Pattukumar V, Arul V, Traditional Indian fermented foods: a rich source of lactic acid bacteria, *Int J Food Sci Nutr*, 64, 2013, 415e28.
- [13] Klein G, Pack A, Bonaparte C, Reuter G, Taxonomy and physiology of probiotic lactic acid bacteria, *Int J Food Microbiol*, 41, 1998, 103e25.
- [14] Ghosh K, Maity C, Adak A, Halder S. K, Jana A, Das A, Parua S, Das Mohapatra P. K, Pati B. R, Mondal K. C, Ethnic preparation of Haria, a rice-based fermented beverage, in the province of lateritic West Bengal, India, *Ethnobot Res App*, 12, 2014, 39e49.
- [15] Ghosh K, Ray M, Adak A, Halder S. K, Das A, Jana A, Parua (Mondal) S, Vagvolgyic C, Das Mohapatra P. K, Pati B. R, Mondal K. C, Role of probiotic *Lactobacillus fermentum* KKL1 in the preparation of a rice based fermented beverage, *Bioresour Technol*, 188, 2015, 161e8.
- [16] Kardong D, Deori K, Sood K, Yadav R. N. S, Bora T. C, Gogoi B. K, Evaluation of nutritional and biochemical aspects of po:roapong (saimod); a homemade alcoholic rice beverage of Mising tribe of Assam, India, *Indian J Tradit Know*, 012, 2012, 11:499e504.
- [17] Arjun J, Verma A. K, Prasad S. B, 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*, 21, 2014, 463e70.
- [18] Teramoto Y, Yoshida S, Ueda S, Characteristics of a rice beer (zutho) and a yeast isolated from the fermented product in Nagaland, India, *World Journal Microbiol Biotechnol*, 18, 2002, 813e6.

- [19] Tamang JP, Thapa S, Fermentation dynamics during production of bhaati jaanr, a traditional fermented rice beverage of the eastern Himalayas. *Food Biotechnol*, 20, 2006, 251e61.
- [20] Roy B, Kala C. P, Farooque N. A, Majila B. S, Indigenous fermented food and beverages: a potential for economic development of the high-altitude societies in Uttaranchal, *J Hum Ecol*, 15, 2004, 45e9.
- [21] Walker G. M, Graham G. Stewart, "Saccharomyces cerevisiae in the production of fermented beverages," *Beverages*, 2 (4), 2016, 30.
- [22] Jolly N. P, Varela C, Pretorius I. S, Not your ordinary yeast: non-Saccharomyces yeasts in wine production uncovered, *FEMS Yeast, Res* 14, 2014, 215–237.
- [23] Swangkeaw J, Vichitphan S, Butzke C. E, Vichitphan K, Characterization of beta-glucosidases from *Hanseniaspora* sp and *Pichia anomala* with potentially aroma-enhancing capabilities in juice and wine, *World J Microbiol Biotechnol*, 27, 2011, 423–430.
- [24] Barnett, J.A, A history of research on yeasts 2, Louis Pasteur and his contemporaries, *Yeast*, 16(8), 2000, 755-771.
- [25] Humia B. V, Santos K. S, Barbosa A. M, Sawata M, Mendonça M. D, Padilha F. F, Beer molecules and its sensory and biological properties: A review, *Molecules*, 24(8), 2019, 1568.
- [26] Johansen P.G, Owusu-Kwarteng J, Parkouda C, Padonou S.W, Jespersen L, Occurrence and importance of yeasts in indigenous fermented food and beverages produced in sub-Saharan Africa, *Frontiers in microbiology*, 10, 2019, 1789.
- [27] Ray M, Ghosh K, Singh S, Mondal K. C, Folk to functional: An explorative overview of rice-based fermented foods and beverages in India, *Journal of Ethnic Foods*, 3, 2016, 5-18.
- [28] Senapati S.S, Saikia D, Bhagawati P, Isolation and Characterization of Amylolytic Yeast Strains Isolated from Indigenous Fruits of Assam, India, *Res. Jr. of Agril. Sci*, 12(6), 2021, 2140–2144.
- [29] Villarreal, P, Quintrel, P. A, Olivares-Muñoz, S, Ruiz, J. J, Nespolo, R. F, Cubillos, F. A, Identification of new ethanol-tolerant yeast strains with fermentation potential from central Patagonia. *Yeast*, 39(1-2), 2022, 128-140.
- [30] Piraine, R. E. A, Retzlaf, G. M, Gonçalves, V. S, Cunha, R. C, Conrad,

- N. L, Bochman, M. L, Leite, F. P. L, Brewing and probiotic potential activity of wild yeasts *Hanseniaspora uvarum* PIT001, *Pichia kluyveri* LAR001 and *Candida intermedia* ORQ001. *European Food Research and Technology*, 2022, 1-16.
- [31] Lengeler, K. B, Stovicek, V, Fennessy, R. T, Katz, M, Förster, J, Never change a brewing yeast? Why not, there are plenty to choose from. *Frontiers in Genetics*, 11, 2020, 582789.
- [32] Nikulin, J, Vidgren, V, Krogerus, K, Magalhães, F, Valkeemäki, S, Kangas-Heiska, T, Gibson, B, Brewing potential of the wild yeast species *Saccharomyces paradoxus*. *European Food Research and Technology*, 246(11), 2020, 2283-2297.
- [33] Piraine, R. E. A, Nickens, D. G, Sun, D. J, Leite, F. P. L, Bochman, M. L, Isolation of wild yeasts from Olympic National Park and *Moniliella megachiliensis* ONP131 physiological characterization for beer fermentation. *Food Microbiology*, 104, 2022, 103974.