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Review article

A REVIEW ON: FERMENTED ALCOHOLIC BEVERAGES; ITS PRESERVATION, SHELF LIFE EXTENSION AND VALUE ADDITION

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Abstract

Background: *Fermented alcoholic beverages prepared from various traditional beers and fruits are on high demands nowadays. These alcoholic beverages are rich in vitamins and minerals essential to our health. So it very essential to find out measures for its preservation, value addition and shelf life extension* ***Objective:*** *The review study focuses on the fermentation various fruit beer and traditional alcoholic beverages and also reviewing the ways for preservation and value addition.* ***Result and discussion:*** *The fruit beers passed by the process of fermentation and aging. Fermentation of fruit wine releases amino acid and other nutrients from the yeast that enhances the nutritive value of the beer product. Several microorganisms are involved in the spoilage, preservation and shelf life extension of the beer.* ***Conclusion:*** *Beers has its own aroma and under suitable condition and by using appropriate method and microorganisms it can be preserve and its value can be enhanced and commercialize.*

Keywords: Fermented, alcoholic beverages, preservation, shelf life, value.

Introduction

The prevalence of traditional alcoholic beverages in the south Asian countries is from the ancient times. These alcoholic beverages are prepared from rice and its name by different names such as Lao- Chao in China, sake in Japan, Tapuy in phillipines, Chongju and Takju in Korea , Brem bali and Tape- Ketan in Indonesia, Khao mak in Thailand, Rou Nep Than in Vietnam and Tapai pulul in Malayasia. Various communities of Northeast India consume their alcoholic beverages it has a great influence in social rituals such as festivals, marriages and even death [1].

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Fruit wine from various seasonal fruits such as pineapple, oranges, banana, cucumber, watermelon, guava, plum, cherries, and strawberry has been prepared at home which works in the conversion of sugar in the fruit juice to alcohol and organic acids[2].

According to Jagtap and Bapat, many tropical, subtropical and temperate fruits have not only nutritional value, but also consumer health benefits as well. Such benefits are related to the antioxidant activity of the phenolic compounds .Combined with a pleasant taste, fruit wines have been shown to be a source of a variety of phenolic compounds with antioxidant activity [3].

Beer fermentation industries are trying to upgrade the production process by enhancing its quality and preservation processes. They are also developing new products that focus on flavors and valued addition by the use of several nontraditional yeast and also the combination of these yeast strains with traditional brewer's yeast at different fermentation stages.eg. *Saccharomyces boulardii, non*-traditional yeast that enhances the nutritional value of low-alcohol beers [4].

Fruits Beers can prepare from various fruits some of are as follows

Jambolan beer

Jamun or jambolan (*Syzygium cumini L*) is a seasonal tropical fruit belonging to the family Myrtaceae. S. cumini, is widely known for several therapeutic and curative properties such as stomachic, carminative, diuretic and digestive. *Syzygium cumini* fruits are difficult to transport over along distance due to its highly perishable nature. So, it can be preserved by processing into various non- alcoholic and alcoholic beverages [5].

Jackfruit beer

The jackfruit (*Artocarpus heterophyllus* Lam., of Family – Moraceae, is a fruit available throughout the tropics and subtropics. The jackfruit is commonly known as poor man's food' due to its low price and high availability during season. It is also widely edible fruit in entire Southeast asia. The jackfruit posses a good antioxidant property and rich source of secondary metabolites such as phenolics and flavonoids. However, due to inadequate storage facilities following maturity and harvest, huge quantities of ripe jackfruits get wasted for rapidly deterioration. Therefore wine fermentation techniques can be applied for processing and preserving underutilized ripe jackfruits in commercial prospects [6].

Mango beer

Mango of the family (*Mangifera indica* L) is a attractive tropical fruit one of the popular fruit of India. It has sweet pleasant taste aromatic flavor and high nutritive value. It possesses many organoleptic properties, and antioxidants like carotene. In India there are about 25 different mango cultivars available. Ripe mango are utilized to produce commercially valuable product such as wine from the excess fruit during the peak season in order to recover the surplus production from loss [7, 8].

Cashew beer

Cashew belonging to the family *Annacardium occidantale* Linn. is one of the most valuable grown crops in India, Nigeria ,Brazil, and Vietnam .Cashew apple is known as “false fruit”and the cashew nut or true fruit is attached below to it. It found in 8 states India such as Kerala, Maharastra, Tamil nadu, Goa, Orissa, Andhra Pradesh, Karnataka and Northeastern states. Cashew apple has high nutritive value and processed for preparation of jam, jelly , pectin, vinegar non- alcoholic and alcoholic beverages as well. Cashew apple have been used to prepare a popular locally available wine brand called “Fenny” in Goa having 40% alcohol content with fovaourable taste, aroma, color, flavor. *Saccharomyces cerevisiae var. bayanus* strain is applied in the fermentation process[9, 10].

Watermelon beer

Watermelon (*Citrullus vulgaris*) is tropical fruit largely available fruits in India throughout the year. It highly produces during summer season and occupies 6-7% of the total fruit production. Edible part of the watermelon is the red colored fleshy part which is sweet in taste and the left out white skin part is considered to be waste. Yeast immobilization in wine fermentation by *Saccharomyces cerevisae* strain 101 was observed in the watermelon pieces(the white epicarp portion of watermelon named as watermelon piece) and observed a better stability and enhanced viability[11].

Pineapple beer

Pineapple (*Ananas comosus*) is a subtropical fruit popular for its attractive flavor and rejuvenating sugar acid balance cultivated and consumed subtropical fruits due to its attractive flavor and refreshing sugar-acid balance. Pineapples are composed of high amounts of essential nutrients and juice content that can be easily processed for wine making [12, 13].

Some traditional alcoholic beverages of northeast India:

Xaj- Pani

From ancient times till to date, various communities in northeast india have been producing alcoholic beverages prepared from rice such as Lao-pani or Xaj pani by the Tai Ahom ethnic community of Assam. In Tai Ahom culture Xaj pani is associated in religious and social belief system. In Production of Xaj pani firstly the rice wass boiled followed by the introduction of the starter cake “Xaj pitha”. Then the process of fermentation is caused by several microbes grown in the culture such as fungi, yeast, and lactic acid bacteria [14].

Poro apong

Poro apong, a famous traditional alcoholic beverages of Mishing Tribe of upper Assam, India. Color of Poro Apong is blackish to reddish brown. It is transparent in nature with aromatic flavor and taste.its preparation undergoes mixing of burn ash of rice husk and straw. Homely prepared yeast culture (epop in Mishing dialect) is used as starter material. Various ailments such as dysentery and body pain can be relived by Poro Apong drinks [15].

Zutho

Zutho or zhuchu prepared from rice, is a popular ethnic alcoholic beverages of the Mao Naga.it is prepared by soaking the rice overnight, drained off, pounded into flour, pour into a big bamboo bucket with boiling water and mix well and kept for cooling. *Khekrii* powder, a locally available amylolytic starter material is added to the culture and kept for 6-8 hours for brewing in a big earthen jar. After 3- 4 days of fermentation a whitish color zutho beer produced with sweet taste and acidic flavor [16].

Jou

Jou is a traditional alcoholic beverages of Bodo community. Cooked rice and the traditional yeast starter culture "Amao" is used in the preparation process. Mashing, fermentation, boiling and preservation processes are involved in the brewing method. The starter cake "Amao" is the composition mixture of pre-soaked rice and medicinal plants such as *Clerodendrum viscosum vent., Scoparia dulcis L., Artocarpus heterophyllus, Musa balbisina, Saccharun officinarum and Scoparia dulcis L*. After two to three days of fermentation a whitish colored rice beer drink is produced from the blend. The shelf life of the beer enhanced up to 15 months by underground airtight storage [17].

Historical account of alcoholic beverages

Earliest evidence wine fermentation from domesticated grapes had been found from Iran dated somewhere between 5400 and 5000 B.C.E [18]. In ancient India, the pre - vedic Harappan people in the Indus valley (ca. 2300 BCE) were familiar with the alcoholic drink production. Several archeological evidence of distillated and fermented beverages obtained from fruits flowers, grains etc [19]. The different traditional alcoholic beverages from Ayurveda. He mentioned about the sugar, fruit and cereal based beer preparation and reported several therapeutic properties. (Cures parasitic infection, promotes digestion, anemia, pulmonary tuberculosis, urine disorder, diabetes etc [20].

Spoilage of beer

Beer spoilage	**References**
For brewing industry, beer spoilage bacteria have been problematic for centuries. They include some lactic acid bacteria such as *Lactobacillus brevis, Lactobacillus lindneri and Pediococcus damnosus*, and some Gram-negative bacteria such as *Pectinatus cerevisiiphilus*, *Pectinatus frisingensis* and *Megasphaera cerevisiae.* They can spoil beer by turbidity, acidity and the production of unfavorable smell such as diacetyl or hydrogen sulfide [21].	Sakamoto, et al. (2003)
Hop bitter acids play a major role in enhancing the microbiological stability of beer. However, beer spoilage lactic acid bacteria (LAB) are able to grow in beer by exhibiting strong hop resistance [22].	Suzuki, et al.(2006)
Lactic acid bacteria (LAB) are the most frequently encountered beer-spoilage bacteria, and they can render beer undrinkable owing to the production of lactic acid, diacetyl and turbidity [23].	Deng, et al.(2013)
The study reported *Bacillus cereus* strain 3012 is a food borne pathogen with strong beer-spoilage ability. It and possessed the beer-spoilage characteristics, such as rendering beer turbid and producing acids and bioamines and showed strong growth in beer supplemented with different hop concentrations It could change the flavor of beer by metabolizing the flavor substances produced [24].	Wang, et al.(2016)
MALDITOF MS is well-suited for the rapid, high-throughput and accurate identification of bacteria isolated from spoiled beer and brewery samples, which makes the technique appropriate for routine microbial quality control in the brewing industry [25].	Wieme, et al. (2014)
Staphylococcus xylolus strain B7 is a beer spoilage strain isolated from craft beer shows high beer spoilage ability at low temperature (4 degree celcius) and low (pH 4) and high ethanol content 7%[26].	Yu, et al. (2019)
The study reported that bacteriophages against Pediococcus and Lactobacillus strains that cause spoilage in brewing processes. A number of beer-spoilage bacteria were isolated from breweries and characterized by 16S rRNA typing. Five distinct *P. damnosus* phages and four Lactobacillus phages, which lysed both *L. brevis* and *L. paraplantarum*, were isolated from municipal sewage and farmyard slurries [27].	Kelly, et al.(2011)

Breweries could potentially use Chitoologosaccharide in the wort as an edible antibacterial material to avoid beer spoilage caused by lactic acid bacteria, without any change in the fermentation profile. Its rather increases the cell viability of the brewer's yeast [28].	Zhao, et al. (2015)
The potential growth of the spoilage bacteria was investigated over 56 consecutive days. A comparison of the results shows a strong inhibition of growth of all spoilage bacteria at 25 mg/L of tetrahydro-*iso*-*α*-acids closely followed by *α*-acids as the second most inhibitory substance. The results showed a high resistance of *Lactobacillus brevis* to all hop compounds as well as an inhibition of *Lactobacillus coryniformis* and *Lactobacillus buchneri* at low concentrations of most hop components [29].	Michael, et al. (2020)
In breweries *Saccharomy cescerevisiae* var. *diastaticus* produces contaminant causing super-attenuation and deterioration in the quality of beer. Changes in concentrations of contaminant were observed in beers stored at 23°C. Spoilage contamination by *Saccharomyces cerevisiae* delayed in cold storage at 8°C [30].	Stulikova, et al. (2021)
Lactobacillus nagelii ABBC668 strain, isolated from spoiled pilsner-type beer, was investigated, as *L. nagelii* has been poorly characterized as a beer spoiler. The beer spoilage ability and hop resistance genes of *L. nagelii* ABBC668 were examined. Results showed that *L. nagelii* ABBC668 harbored hop resistance gene *horA* and exhibited beer spoilage ability [31].	Umegatani, et al.(2020)
Bacteriocin producing *P. acidilactici HW01* was isolated from malts very effective to inhibit major beer spoilage lactic acid bacteria (*P. damnosus* and *P. claussenii*). The bacteriocin activity was stable over a wide range of pH, detergents, solvents, and resistant to high temperature which are often encountered during brewing [32].	Ahn,et al.(2017)
This research work reported that beer spoilage microbial strains posses different resistance against acid washing treatment of brewer's yeast.	Munford, et al.(2020)

Lactobacillus brevis DSM 6235 demanded almost 50 min for the first demcimal reduction at (pH 2.0). While *Pediococcus damnosus* DSM 20289 demanded almost 70 min for 4 log reductions to be achieved and pH reduction of the acid washing from 2.0 to 1.5 allowed 4 log reduction of L. brevis DSM 6235) to be obtained in less than 50 min, without ruining brewer's yeast viability. Therefore contaminants potentially present in brewing yeastsinactive the most resistant bacteria by acid washing at pH 1.5 [33].	

Preservation and Shelf life of fermented alcoholic beverages:

Preservation & Extension shelf life	References
Shelf life of sorghum beer may be extended by removal of the second step of malt conversion during fermentation reduces the amount of total acid production which proportionally decreases the bacterial load to 3.3 log cfu/ml, while the duration of spoilage was extended from 168h to 240 h in comparison to the normal product [34].	Kutyauripo, et al. (2009)
Lysozyme as an antimicrobial enzyme posses a strong inhibitory action on the lactic acid bacteria (LAB) which gives stability and enhanced the self life [35].	Silvetti, et al.(2010)
Marked extension in shelf life stability of "atingba" was observed with the addition of *Albizia myriophylla* bark and finds substantial application in the food industry as a natural food supplement and preserving agent [36].	Deka, et al. (2016)
Mesoporous zirconium phosphate (M-Zrp), which is an inorganic nano material with apertures in the range of 2–50 nm. It could be used as an antibacterial agent against beer-spoilage organisms. . The results showed that M-Zrp showed bacteriostatic activity against *Saccharomyces diastaticus*, *Candida albicans*, *Pediococcus damnosus*, and *Escherichia coli* [37].	Zhou, et al.(2014)
The *Lactobacillus plantarum* strains with their probiotic properties can have great effects against harmful microflora (food borne pathogens) to increase safety and shelf-life of fermented foods [38].	Behera, et al. (2018)
Shelf life of wine can be extent by several methods such as fining, filteration, disinfection, sulfur dioxide addition, Bottle Closure and	Jackson, (2016)

Orientation, Temperature Control etc [39].	
Use of starter cultures also can increase the chances of preserving traditional Alcoholic beverages, giving them a longer shelf life. Moreover, *Vernonia aemulans* and *V. amygdalina* leaves can be used as hops substitutes in the local brewing context due to their strong antimicrobial activity imparting extended shelf life with less harmful effects, and to their brewing properties such as bitterness and aroma precursors [40].	Lyumugabe, (2019)
Two different types of rice beer undergo self life study and observed BS-2 with microflora from Hamei had a better shelf life than BS-1 produced with established culture [41].	Deka, al. (2017)
Preservation of food for its safety and long shelf life is dependent on the food type and properties (pH, water activity, nutrient content, antimicrobial constituents, etc.), initial microbial flora, and processing and storage conditions (heating, acidification, reduced water activity, storage atmosphere, chilled storage, etc.). The review deals with food spoilage, microbes causing food contamination, prevention of microbial spoilage, and preservation of foods [42].	Abdel-Aziz, et al. (2016)
The self life of the fermented “pito” can be extended by two days by the application of commercial prepared starter culture of *Lactobacillus delbrueckii* and active dried S. cerevisiae in comparision to the tradition fermented “pito” [43] .	Djameh, et al.(2019)
Thermosonication as an alternative method for the pasteurization of pulque in order to improve its shelf life and retain its quality parameters.The optimal conditions found for processing pulque by thermo-sonication were at 75% for 6 and 9 min and 85% for 4 and 6 min. These conditions allowed the survival of lactic acid bacteria and yeasts that can develop during storage and that can preserve the quality of pulque. Thermosonication achieves the extension of the shelf life of pulque up to day 24 of storage at 4 °C. At the same time, sensory and physico-chemical properties such as color, alcohol content, and acidity were conserved [44].	Alcantara-Zavala, et al. (2021)
L.planatarum (ATCC 8014) strain produces microorganism. It can be used as a biological preservative for pineapple wine. Bacteriocin producing ability and antimicrobial activity of *L.planatarum* was detected against *S. cerevisae*, *E.coli*, *S. aureus* and *B.subtilis*, *L.acidophilus* strains as indicator [45].	Kumari, et al.(2021)
This study reported that Pediococcus acidilactici K10 can be used as biological preservative. This strain can be used as a measure for bioacidifying the mash and reducing the spoilage of the beer. The K10 strain showed antimicrobial activity against two beer spoilage LAB strains in wort that were unable to grow in a beer environment [46].	Kim, et al.(2016)

Application of new strain for value addition in fermented alcoholic beverages

Strain	Function	References
Bacillus licheniformis	Bacillus starter culture shows improved results in sensory appraisals which indicates that *B.licheniformis* was one of the main species influencing the aroma characteristics of Moutai flavoured liquor [47].	Zhang, et al. (2012)
Schizosaccharomyces pombe	The breakdown of malic acid, production of pyruvic acid and the breakdown of ethyl carbamate precursors, are of great interest in modern winemaking. However, its major drawback is its strong acetic acid production at least for the unselected strains commonly used in wine research and finally concluded that the selection of *Schizosaccharomyces* strains with high urease activity can be developed as a new tool to assure wine safety[48].	Benito, et al. (2012)
Saccharomyces cerevisiae, Lactobacillus plantarum.	*P. mahaleb* fruits after fermentation with different *Saccharomyces cerevisiae* and *Lactobacillus plantarum* protechnological strains. The adopted protocol allowed us to attain edible fruits and a new fermented non-dairy drink with valuable probiotic health-promoting properties. This investigation confirmed the potential of yeasts and lactic acid bacteria co-inoculation in the design of starter tailored for this kind of food applications [49].	Gerardi, et al. (2019)
Torulaspora delbrueckii.	Enzymatic hydrolysis alcoholic fermentation (EHAF) treatment could significantly improve the production of aroma compounds and this strategy might be a useful way in fruit alcoholic beverage fermented with *Torulaspora delbrueckii* [50].	Guo, et al. (2018)

Lactobacillus plantarum	*Lactobacillus plantarum* (widespread member of the genus Lactobacillus) is one of the most studied species extensively used in food industry as probiotic microorganism and/or microbial starter. *Lactobacillus plantarum* strains with their probiotic properties can have great effects against harmful microflora (foodborne pathogens) to increase safety and shelf-life of fermented foods [51].	Behera, et al. (2018)
Saccharomyces cerevisiae var. boulardii	Perform analysis of experimental beers for the content of main volatile compounds showed that the inclusion of *Saccharomyces cerevisiae var. boulardii* strain in mixed starter did not affect negatively beer aroma. Moreover, the inclusion of *Saccharomyces cerevisiae var. boulardii* strain in mixed starters determined an increase in the antioxidant activity and polyphenols content, in comparison to beers from single starter fermentations, indicating the influence of *Saccharomyces cerevisiae var. boulardii* strain on these parameters [52].	Capece, et al. (2018)
Saccharomycodes .ludwigii, DBVPG 3010.	*S.ludwigii* strain was recognized to be good yeast species for low alcohol and alcohol free beer production. Beer fermentation by using *S.ludwigii* DBVPG 3010 it showed lowest ethanol content (0.5% v/v) [53].	Frencesco, et al. (2014)
olive (Olea europaea L.) leaves	The effects of olive leaves addition were evaluated through following analysis: total polyphenols content, oleuropein and 3-hydroxytyrosol content, antioxidant capacity, sensory analysis, shelf-life prediction. Results confirmed that addition of olive leaves highly increased polyphenol content of beers. Boiling time favored hydrolysis of oleuropein to 3-hydroxytyrosol. Antioxidant activity was not influenced by addition of olive leaves [54].	Guglielmotti, et al.(2020)
Lachancea fermentati KBI 12.1	*Lachancea fermentati KBI 12.1* proved to be a suitable strain for brewing purposes, with promising traits with regard to nonalcoholic and low alcohol beer brewing [55].	Bellut, et al. (2019)

G.geotrichum,K.zonata,K.lactis,L. Meyerae,P.kluyveri,S.caribae,Y.lipolytica and S.ludwigii.	The study reported that fermentation capacity of wort, grape and apple juice using non- Saccharomyces yeast produce pleasant aroma compounds under relevant fermentation conditions [56].	Gutierrez, et al. (2018)
Lactobacillus paracasei L26, *Saccharomyces cerevisae S-04*	*Lactobacillus paracasei* L26 a probiotic bacterium were cofermented with a brewer's yeast , *Saccharomyces cerevisae* S-04, The majority of fermentable sugars were attenuated by S. cerevisiae S-04 with a concomitant production of alcohols and esters and *L.paracasei* L26 produces a significant amount of lactic acid. Therefore the result suggest the utility of lactobacilli as a probiotic starter cultures in the beer industries[57].	Chan, et al. (2019)
Lachancea thermotolerans	The study suggested that *L. thermotolerance* is a good choice for producing sour beers in single fermentation step without using lactic acid bacteria [58].	Domizio, et al. (2016)
Torulaspora delbrueckii	Two other strains could possibly be used for pre-fermentation as a bio-flavouring agent for beers that have been postfermented by Saccharomyces strains as a consequence of their low sugar utilization but good flavour-forming properties [59].	Michel,et al. (2016).
Torulaspora. delbrueckii Prelude & *L. thermotolerans Concerto*	Non-Saccharomyces yeast strains such as *T. delbrueckii* Prelude and *L. thermotolerans* Concerto showed a acceptable fermentative results. A good alcoholic fermentation performance in terms of ethanol production and produced significantly higher amounts of acetyl esters and long-chained ethyl esters observed in both the strain. Conversely, *T. delbrueckii* Biodiva synthesise significantly	Toh, et al. (2019)

	higher amounts of some favourable volatiles including isoamyl alcohol and ethyl butanoate while being most effective in terpene retention and release, making it a promising strain for low-alcohol beers [60].	
C.zemplinina Y.01670	The *C. zemplinina Y.01670* strain showed a variable production of ethanol when malt wort along with adjuncts was tested. The use of this yeast strain and the adjuncts would probably enable producing a broad variety of beers with special sensory characteristics and variable ethanol content [61].	Estela-Escalante, et al. (2017)

Conclusion:

The review study done on several traditional rice beer and fruit beer and observed strains of *Lactobacillus*(*Lactobacillus brevis & Lactobacillus lindneri), Bacillus cereus* strain 3012, *Staphylococcus xylolus strain B7,Saccharomy cescerevisiae* var. *diastaticus etc* responsible for the early spoilage of the beer. The preservation and shelf life extension processes could be enhanced by plants leaves such as *Vernonia aemulans* and *V. amygdalina* leaves, *Albizia myriophylla* bark and methods like Thermosonication as well as by various microbial strains such as *Pediococcus acidilactici* K10, *Lactobacillus plantarum(ATCC 8014)*, *Lactobacillus delbrueckii etc.* On the other hand, strains like *Bacillus licheniformis*, *Saccharomyces cerevisiae var. boulardii*, *Schizosaccharomyces pombe*, *Torulaspora delbrueckii etc* contribute to the improvement of the quality and value of the product for effective commercialization.

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