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## Journal of Ethnic Foods

journal homepage: <http://journalofethnicfoods.net>

## Review article

## Folk to functional: An explorative overview of rice-based fermented foods and beverages in India

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## ARTICLE INFO

## Article history:

Received 7 January 2016  
 Received in revised form  
 18 January 2016  
 Accepted 27 January 2016  
 Available online 26 February 2016

## Keywords:

fermented beverages  
 functional components  
 health benefits  
 microflora  
 rice

## ABSTRACT

Fermented foods share an integral part of age-old wisdom from ancient Indian civilization. Over the generations, this pioneering practice of food fermentation has expanded and improved to preserve and fortify the available food resources, particularly to meet the hidden hunger. India, being the second largest producer of rice, has a great history of traditional rice-based fermented foods with different tastes and textures linked with cultural diversity and mostly prepared by rural women following village art techniques. Some of them have been scientifically investigated and it has been revealed that microflora in natural or starter culture plays imperative roles to bio-embolden the rice with varieties of health promoting macronutrients and micronutrients, phytochemicals, and other functional components during fermentation. In this review, some explorative information on traditional rice-based foods and beverages has been assembled to illustrate the global interest in Indian food heritage and their functional aspects. The review also deals with the preparation of raw materials, traditional processing, composition, and ethno-medicinal importance of each food to encourage entrepreneurs to develop large-scale production to meet the growing market demand of functional foods.

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## 1. Introduction

On the Indian subcontinent, fermented foods and beverages are an integral part of cultural heritage, even today. These have been developed throughout the history of human civilization for sustained nutrition and food preservation [1,2]. Fermentation leads to changes in appearance of food characterized by quite different properties and uses. Ancient people adopted different preservation methods to store excess foods of plant and animal origin, particularly those which are seasonal and have a short lifespan (perishable). On this basis, it is presumed that fermented foods probably originated during 7,000–8,000 BC in the areas of Indus Valley [3]. It is evident from the annals of the Harappan civilization (Vedic period) that people used different clay pots for preparing fermented foods and drinks [4]. Fermented milk products, alcoholic beverages from fruits and cereal grains, and leavened breads were very popular among the early civilization in the Middle East and in the Indus Valley and later among the Egyptians, Greeks, and

Romans. The health-beneficial effects of fermented food were first advocated as far back as 76 AD by the Roman historian Pliny, who mentioned the use of fermented milk for treating gastrointestinal infections. In the late 1700s, Lavoisier revealed the chemical basis of sugar transformation. Around 1850, the great French chemist, Pasteur, discovered the biological basis of fermentation and identified the particular role of microbes that initiate and continue the fermentation process [5]. In the early 1900s, Tissier, a French pediatrician, proposed that bifidobacteria in food could be effective in preventing infections in infants [6]. This health-beneficial concept of fermented foods has matured through extensive scientific interventions, particularly over the past 2 decades, thereby increasing consumer awareness of the functional basis for ingesting such traditional foods in relation to health promotion and disease prevention [7–10].

Currently, > 5,000 different fermented foods are consumed by mankind worldwide, many of which are ethnic and produced in small quantities to meet the needs of groups in a particular region. Traditional fermented foods are defined as foods produced by native people using their ancestral knowledge and artisanal techniques from locally available raw materials of plant or animal sources. These are prepared either naturally or by adding starter

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culture(s) containing functional microorganisms which modify the substrates biochemically and organoleptically into edible products that are culturally and socially acceptable to consumers [11]. The ethnic food fermentation process was modified continuously through the propagation of traditional knowledge and experiences from one generation to the next, particularly keeping in mind improved sensory qualities and safety. The idea of fermented food preparation also expanded with diverse locally available substrates including grains, vegetables, milk, fish, and meat products [12]. The rural folk are found to prefer the fermented foods over the unfermented, because of their pleasant taste, texture, and color [13].

Traditional fermented food preparation is one of the oldest biotechnological processes around the world in which microorganisms play a crucial role in improvement of sensory characteristics, bioenrichment, health promoting attributes, and preservation of foods. Fermentation helps to reduce nondigestible carbohydrates, enriches the pool of essential amino acids, vitamins, and minerals, and increases the overall quality, digestibility, taste, and aroma of the food [14,15]. This extraordinary benefit of fermented food is helpful to maintain the healthy composition of intestinal microbiota that are essential for protection from various diseases and to maintain physiological homeostasis and the gut–brain relationship of the host. From this point of view, fermented food is designated as “naturally fortified functional food”. The term “functional food” was first introduced in Japan in the mid-1970s. It refers to processed foods containing physiologically active ingredients that aid specific bodily functions beyond basic nutrition [16,17]. A recently proposed working definition of functional food is: “food that can be satisfactorily demonstrated to affect beneficially one or more target functions in the body, beyond additional nutritional effect, in a way relevant to an improved state of health and wellbeing and/or reduction of risk of disease” [18,19].

Global interest in cereal-based fermented products is increasing due to low fat/cholesterol, high minerals, dietary fibers, and phytochemicals content [15]. Beyond the basic nutrients, cereal-based fermented food confers several health promoting attributes, as it contains edible beneficial microbes, also called probiotics, fermentable sugars (of microbial and food origin, i.e., prebiotics), and digestive aids such as a group of microbe-derived hydrolytic enzymes, etc. In addition, multistrain or multispecies probiotics may provide greater beneficial effects than monostrain cultures. The synergistic actions of these exogenous microbiota create a sociable environment for commensals (native colonizing organisms), prevent the growth of otherwise enteropathogens, are beneficial for digestion and absorption, produced different metabolites including short chain fatty acids, especially butyrate, which have a positive effect on epithelial lining of the gastrointestinal tract, enhance mucosal cell differentiation, and this may also promote the immune barrier function of the epithelium, and on peristalsis, which improves transit [20,21]. Cereal components are the natural growth media/carriers for probiotics and have a buffering capacity to protect the organisms in the harsh environment of the intestine [22]. Considering these beneficial effects, the grain-based fermented foods have now become more popular than conventional dairy-based products, particularly in Japan and Europe [23]. The market of nondairy probiotic beverages is expanding, with a projected annual growth rate of 15% (between 2013 and 2015). It is predicted that the market will reach €65 billion by the year 2016 and on this, dairy-based produce accounts for approximately 43% of the market [24].

The art of preparation of different types of dishes from fermented rice or rice-mixed cereal/pulse products is a well-known practice in India. These foods are important components of the diet as staples, adjuncts to staples, condiments, and beverages. In India, diversity of rice-based traditional fermented foods is related

to diversity of ethnicity in each community [25,26]. Rice-containing foods are fermented by a mixed culture of microorganisms by spontaneous fermentation and, in the case of beverages, by adding a starter culture. These are prepared in households or in cottage industries using relatively simple techniques and equipment [26]. In the recent past, there were no verified data on the nutritional, technical, and quality control implications of indigenous rice-based fermented food products in India, the second most populated rice production country in the world. However, in the past 20 years, a number of books and articles dealing with indigenous rice-based fermented beverages and foods have been published. In this context, this review focuses on the unexplored mystery of microbial interplay in rice-based indigenous fermented foods and beverages, and emphasizes the importance of the bioactive functional biomolecules. This will offer ample scope for researching and protecting the traditional knowledge through intellectual property rights and will be helpful for commercialization of these indigenous food products [27].

## 2. Indian perspective of fermented food diversity

The term fermentation is derived from the Latin word *fermentum*, which stands for boiling. It may be defined as any process for the formation of a product by the mass culturing of microorganisms [28]. Fermented food preparation, as mentioned in literary texts, is more than 3,000 years old in India [29]. The Rgveda (1,500 BC) shows that fermentation technology took its first step in connection with the preparation of *soma* juice (alcoholic beverage). There is also another drink, known as *sura* (wine/beer), prepared by fermentation of boiled rice/barley [13]. It is known from different sources that during the post-Vedic period (600 BC to 100 CE) many beverages like *medaka* (spiced rice beer), *prasanna* (spiced barley or wheat beer), *asava* (sugarcane beer), etc., were some of the most popular drinks. Some new recipes for fermentation were also formulated. One such recipe was described in Rasopanisat (RP. XV 251–253). The recipe was: “The best ones among the five classes of bulbous plants with latex are pounded along with the grains of rice of *Kodrava* (*Paspalumscrobiculatum*), and products of plant *madana* (emetic nut) are pasted with whey from water buffalo or cow milk and kept in a closed bowl. The closed vessel is then placed in the sun. The acidic residue thus obtained is *kinva* (yeast)”. Another recipe was *sukta*: a mixture of treacle, honey, fermented rice, water, and whey. This mixture was placed in an earthen pot and the pot then placed on heaps of paddy for 3 nights in the summer season. Another recipe was also known as *kanjika*: boiled millet or barley was used as a base material. Different plants were added into the fermented medium. It could also be prepared by using boiled rice [30].

Native people possessed an immense knowledge on the environment and suitability of plant and animal products as edible and wholesome foods. They understood the functioning of the ecosystem and techniques of using and managing plants and animals [31]. Indigenous food fermentation is an efficient approach for preparation and preservation of food by unknowingly using microorganisms [13,25]. During fermentation, people used very simple and common utensils and locally available ingredients. According to the nature of common plant and animal resources, indigenous fermented foods can be categorized as cereal- and/or pulse-based, vegetables, beverages, wine, milk, and fish- and meat-based products [32]. They are very popular due to their specific organoleptic properties, caloric value, health benefits, and extended shelf life. Apart from own composition, people used the fermentation process for the production of colors/dyes, ingredients as fish bait, animal feed, etc. [11,13].

Even today in India, fermented foods and beverages are taken by people of both of low and high income groups [21]. The traditional

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