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Usage of traditional fermented products by Indian rural folks and IPR

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Documentation and utilization of traditional knowledge in the field of medicine, healing and biodiversity conservation has attained greater dimensions. Though rural folk of our country unknowingly use microorganisms for varied purposes, there is no major effort to document and protect them. The art of preservation and enrichment of vegetables by microbial systems, preserving microbial culture starter for beverage production and production of diverse traditional beverages from plant materials is commendable. Fish products, dye adhesives and dyes are obtained similarly. Traditional foods and beverages are also used therapeutically. Patent analysis of Indian traditional fermented products in Indian databases, viz. Ekaswa A, Ekaswa B and Patestate showed the presence of few patents in *idli*, *kinema*, and *toddy*. In the United States patent database, there are few patents in *dahi*, where the relevance knowledge from India is indicated. Search in the patent databases of Japan, Europe and global search of WIPO showed lack of patents in Indian traditional fermented products. There is ample scope for researching and protecting our traditional knowledge by the tools of Intellectual Property Rights and sharing of benefits with the indigenous people of our country.

Key words: Traditional fermentation, Traditional foods, Traditional beverages, Culture starter, Patent analysis

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Indigenous people possess an immense knowledge of their environments. They have an understanding of the properties of plants and animals, the functioning of ecosystems and techniques of using and managing them[1]. Traditional knowledge in the field of healing and biodiversity conservation is also well known[2]. However, traditional knowledge in other aspects is not carefully documented. It is essential that science and traditional knowledge should go together to find mutually beneficial results. In the Indian subcontinent, making use of fermented food and beverages using local food crops and other biological resources are very common[3]. But the nature of the products and the base material vary from region to region. Fermentation has been used for a long time as an effective and low cost means to preserve the quality and safety of the foods. Food fermentation involves mixed cultures of microorganisms that grow simultaneously or in succession. One can contemplate that indigenous people are using microorganisms unknowingly for varied purposes. Apparently, exploitation of microorganisms for food and beverages purposes are seem to be the only contribution of indigenous people. But a careful analysis may reveal the intellectual richness of indigenous people of our country in terms of their ability in preparing microbial products for varied purposes in addition to food and beverages. Further, such kind of undocumented knowledge systems is in the danger of extinction due to various causes. It is important to enforce protection measures based on the mandates of Convention on Biological Diversity (CBD) like *sui generis* system or to evolve suitable IPR measures with a safeguard for benefit sharing with holders of such traditional knowledge[4, 5]. The paper aims to document the richness of microbial traditional knowledge of Indian people with an analysis on IPR specifically on patents to find out the scope of protecting such knowledge. The paper shall further hint out on the scope of modern microbiological explorations and investigations in this arena of traditional knowledge.

Common indigenous fermented cereal and /or pulse foods

Fermentation is one of the oldest forms of food technology in the world. Indigenous fermented foods have been prepared and consumed for thousands of years, and are strongly linked to culture and tradition. The fermented foods are better than normal cooked food varieties in terms of nutrition, amenability for

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digestion, etc. The fermentation process causes enrichment and improvement of food through flavour, aroma, and change in texture, preservation by producing organic acids, nutritional enrichment, reduction of endogenous toxins and reduction in the duration of cooking and thereby fuel requirement[6]. Indigenous food fermentation is one of the oldest biotechnology process in which microorganisms play an essential role in production and preservation. During traditional fermentation processes, locally available ingredients, which may be of plant or animal origin, are converted into edible products by the physiological activities of microorganisms[6].

Idli, Dosa, Dhokla and Khaman

Idli is a popular traditional fermented food, prepared and consumed throughout India, particularly in southern parts of India and in many parts of Sri Lanka[6]. It is consumed mainly as breakfast along with chutney and *sambar* [coconut and *dhal* (pulse) based preparation, respectively]. It is acid leavened steamed cake made from rice and unhulled black gram *dhal*. This traditional food is a good source of protein and calorie. They are easily digested and often used as food for infants and invalids[6]. Normally *idli* fermentation is a natural fermentation. Sometimes, sour buttermilk or yeast is added to enhance fermentation. *Leuconostoc mesenteroides*, *Streptococcus faecalis* and *Pediococcus cerevisiae* are the significant microorganisms involved in the fermentation process[7]. The essential physical change in the batter is that it becomes leavened by CO_2 gas as well as pleasant flavour develops[6]. *Kancheepuram idli* is a type of popular *idli* among Tamil indigenous people. During its cooking, cashew nuts, ghee, salt, pepper, ginger, and cumin are added to enhance taste. In *idli* made with 1:1 proportion of rice to black gram, batter volume increased about 47%, the *p*H fell to 4.5 and total acidity rose to 2.8% (as lactic acid) during 12 - 15 hrs of fermentation at 30°C[6]. Common finger and foxtail millets are substituted for a proportion of the rice in making *idli* in combination with black gram *dhal* (2 parts rice: 1 part black gram *dhal*). Even total replacement of rice with common millet yielded *idli* acceptable in flavor and texture, but a combination of 25% common millet with 75% rice is rated still better[6]. The content of both thiamine and niacin gets increased but riboflavin remained the same. Volume increase of this *idli* batter during fermentation is from 1.5-2.5 times of starting volume while the *p*H fell from 5.7 to 4.5-4.8[6]. In *idli* preparation, instead of rice, *kodri* (*Paspalum scorbiculatum* Steud.) and soybean or green gram (*Phaseolus aureus* Roxb.) instead of black gram are also used[6]. In *dosa* preparation, wheat, bajra (*Pennisetum typhoideum* Rich.), maize or *kodri* instead of rice and sprouted peas, cowpea (*Vigna catjang* Walp.), field beans (*Dolichos lablab* L.), soybeans or fresh groundnut oilcake instead of black gram are used. In *dhokla* preparation, coarsely ground meals of wheat, maize or *kodri* (*Paspalum scorbiculatum* Steud.) instead of rice and soybean, peas, red gram [*Cajanus cajan* (L.) Druce], moth beans (*Phaseolus aconitifolius* Jacq.) instead of Bengal gram is used[6].

Dosa batter is similar to *idli* batter but the batter is thinner[6]. After fermentation, the leavened *dosa* batter is baked on hot pan as thin, crisp pancake and eaten with chutney and *sambar*. *Dhokla* is also similar to *idli*, but black gram is replaced by Bengal gram in the preparation[7]. *Khaman* is similar to *dhokla*, but it is made entirely of Bengal gram *dhal*. *Idli, dhokla* and *khaman* are steamed as soon as the batter is leavened and acidified. They are consumed the same day. The acid content retards the growth of food poisoning and food spoilage organisms.

Kinema

It is usually consumed by indigenous people of eastern Himalayan regions of Darjeeling hills and Sikkim as a good and cheap source of protein[8]. It is a fermented, ammonia flavoured, alkaline food prepared from soybeans. The product of fermented soybean is salted, deep fat fried and consumed along with rice and vegetables. It is also consumed as a soup along with green vegetables[9]. *Bacillus subtilis* is the predominant microorganism in *kinema. Enterococcus faecium, Candida parapsilosis* and *Geotrichum candidum* are also involved. Water soluble nitrogen and formol nitrogen to total nitrogen content of *Kinema* increased rapidly during fermentation[8]. This is due to high proteolytic activity of *B. subtilis*. The *p*H rises until the aroma becomes ammonia like. Ammonia concentration may rise up to 200mg/100gm of *Kinema*, indicating high level of proteolytic activity with the release of free amino acids followed by de-amination[9]. The *p*H rises as high as 8.6 after 32 hrs of fermentation.

Jalebi

It is a sweetened fermented product made from maida (refined wheat flour), dahi and water[6]. The

fermented batter is deep fat fried in oil in spiral shapes and immersed in sugar syrup for few minutes. This traditional food is prepared during marriage ceremonies and festivals of South India. *Lactobacillus fermentum* (6×10^8/gm), *L. buchneri* (3.2×10^8/gm), *Streptococcus lactis* (6×10^8/gm), *S. faecalis* (6×10^8/gm) and *Saccharomyces cerevisiae* are found in the fermented batter. The pH decreases from 4.4 - 3.3 and there is a 9% volume increase in the batter. Both amino nitrogen and free sugar decrease during fermentation[6].

Fermented rice and *Ambali*

Fermented rice food is prepared by adding water to cooked rice and incubating the mixture overnight. The water is drained off and used to cook vegetables or mixed with buttermilk and salt for direct consumption. Rice is mixed with *dahi* and salt. *Streptococcus faecalis* (2.7×10^7/gm), *Pediococcus acidilactici* (2.7×10^7/gm), *Bacillus* sp. (1.6×10^8/gm) and *Microbacterium flavum* (1.1×10^8/gm) have been isolated from *fermented rice*. The *p*H is decreased from 6.1 to 5.7 in 16 hrs. There is no change in volume, amino nitrogen or free sugar[6].

Ambali is a fermented product from ragi [*Eleusine coracana* (L.) Gaertn.][10]. *Leuconostoc mesenteroides* (1.6×10^9/gm), *Lactobacillus fermentum* (1.6×10^9/gm) and *Streptococcus faecalis* (8×10^8/gm) have been isolated from fermented ragi. The *p*H decreased from 6.4 to 4.0 and volume increases by about 20%, indicating CO_2 production[10].

Sez

The traditional semi-fermented food used by the *Bhotiyos* in Uttaranchal is called *sez*. It is made from rice and mostly used as snacks. Earlier, it was a delicacy and was prepared only during certain festivals. In most cases, *sez* is extracted during the preparation of rice *jann*[3].

Other fermented foods

In addition to the above, various types of traditional fermented foods like *Bhallae* (black gram product), *Bhatura* (white wheat flour product), *kulcha* (white wheat flour product), *Nan* (wheat flour product), *warri* (black gram product), *Papadam* (black gram product) and *Vadai* (black gram product), are prepared[11].

Indigenous fermented vegetable foods

Mesu

Indigenous people of eastern Himalayan regions of Darjeeling hills and Sikkim use the fermented bamboo shoot product called mesu as pickle and base of curry. The fermentation of *mesu* is initiated by *Pediococcus pentosaceus* followed by *Lactobacillus brevis* and finally dominated by *L. plantarum*. The *p*H of *mesu* is declined from 6.4-3.8 due to increase in titratable acidity from 0.04- 0.95 %[12].

Sinki

It is an acid non-salted fermented radish taproot consumed as the base of soup or as pickle by indigenous people of Nepal, Darjeeling, Sikkim, and Northeast India[6]. For consumption, *sinki* is immersed in water for 2 min, after removing water; it is fried with salt, onion and green chilli. The fried mixture is boiled in rice water and consumed as soup along with main meal[6]. *Sinki* has 14.5 % of protein, 2.5% of fat and 11.3 % of ash on dry weight basis. This fermentation is initiated by *Lactobacillus fermentum*, *L. brevis* and followed by *L. plantarum*[13].

Pickles

Dry salted lime pickle is a popular home made fermented product. In India, the pickle is very spicy and hot due the addition of chilli. During preparation, the well ripened lime fruits are washed with water, cut into pieces and mixed with salt, then allowed for fermentation in clay or earthen pots for a week. By similar methods, cucumber, Indian gooseberry and mango pickles are prepared. *Khalpi* is a traditional cucumber pickle used in the Himalayan region of India[14].

Sauerkraut

It is a type of preserved fermented cabbage (*Brassica oleracea* L.) food[6]. After fermentation, Indians use this as a base of curry. The fermentation is started by *L. mesenteroides* and followed by *L. plantarum*[6].

Gundruk

It is a fermented vegetable of rayo (Brassica campestris L.var. cumifolia Roxb.) or radish or cauliflower and used as a base for soup[15].

Fermented milk foods

Dahi and Rabdi

Dahi is a lactic acid fermented product of cow or buffalo milk[6]. It is consumed directly either as sweetened or as salted and spiced form. It is also

consumed with other food such as rice and *chapatti*. It is consumed more in summer than winter. The vitamin content of the *dahi* depends upon the type of organisms used for fermentation. The mixed culture of *Lactobacillus bulgaricus* and *L. cremoris* in *dahi* decreased the level of thiamine, riboflavin, and nicotinic acid. But single cultures of *Streptococcus lactis* and S. *cremoris* raised the thiamine concentration from 2-20 % over that of milk. The *p*H of the *dahi* is in the range of 4.6-5.0[16]. *Rabdi* is a milk-cereal based fermented product made from cooked maize flour and buttermilk. *Pediococcus acidilactici* (3.6×10^5/gm), *Bacillus* sp. (1.1×10^6/gm) and *Micrococcus* sp. (7.9×10^5/gm) have been isolated from fermented *rabdi*. The *p*H changes from 6.7-6.4 and there is slight increase in volume (by 5%). There is no change in amino nitrogen or free sugar[6]. In addition to *dahi* and *rabdi*, there are other fermented milk products like *paneer, shrikhand, misti dahi* and *chhurpi*, which are used in northern, western, eastern and Himalayan region of India, respectively[14].

Fermented indigenous fish foods

Ngari, Hentak and Tungtap

Usually, the fishes are preserved by sun drying and salting. In southern East India, the fishes are traditionally preserved by fermentation, salting, drying and smoking. In Northeast India, traditionally preserved fish products are called *Ngari* and *hentak* in Manipur and *tungtap* in Mehalaya[17]. *Ngari* is consumed as a side dish with cooked rice. *Hentak* is consumed as curry as well as condiment with boiled rice. Ethnic people of Manipur consume both the products. *Khasi* tribes of Meghalaya consume another type of fermented fish product as pickle namely *tungtap*. Fermented fish product of *ngari, hentak* and *tungtap* has *Lactococcus lactis, L. plantarum, Enterococcus faecium, Lactobacillus fructosus, L. amylophilus, L. coryniformis, L. plantarum, Bacillus subtilis B. pumilus, Micrococcus* sp. *Candida* sp., and *Sacchromycopsis* sp[17].

In general, most of the indigenous foods are acidic in nature and their *p*H ranges from 3.8-4.8 while some are slightly acidic in the range of 5.7-6.4 *p*H. Certain foods like *kinema* are alkaline with a *p*H of 8.6. Acidity is due to the production of organic acids like lactic acid by the fermentative reaction of microorganisms over the carbohydrate substrates present in the cereal ingredients of such food. The alkalinity is due to the generation of ammonia by the proteolytic activity of microorganisms in those foods, where proteins are abundant due to the use of pulses as a major ingredient or as the sole component.

Culture starter for fermented beverage production

Keem

It is used as a starter material for the preparation the beverage namely *soor* [18]. For *keem* preparation, the fresh twigs of *Cannabis sativa* L., leaves of *Sapindus mukorossi* Gaertn. and approximately 40 herbal plant materials dried in shade, powdered and mixed with barley flour. The desired quantity of above dried flour is mixed with sufficient quantity of *jayaras* (an infusion prepared from finely chopped leaves and tender parts of *Melia azedarach* L., *Zanthoxylum armatum* DC., *Leucas lanata* Benth. *and Dicliptera roxburghiana* T. Anders.) in a large container for overnight and made into round cake. The cakes are placed on the plant bed made up of tender shoots of *Cannabis sativa* L. and *Pinus roxburghii* Sarg. alternatively between the cakes in a closed room. This set up is kept undisturbed for 24 days. On 25th day, the cake is turned up side down and again kept undisturbed for 12 days. Then, the cakes are dried in the sun or open air and stored[18].

Murcha

The beverages of indigenous people of Darjeeling hills and Sikkim are prepared using starter culture materials. *Murcha* is a traditional starter, used to produce sweat sour alcoholic beverages called *jnards*[19]. *Murcha* cakes contain 13% w/w moisture, 0.7%w/w ash on dry weight basis and mildly acidic (*p*H 5.2). The microflora of *murcha* was reported to contain *Pediococcus pentasaceus* (2.0×10^7-4.2×10^8/gm), *Saccharomycopsis fibuligera* (4.0×10^7-6.8×10^8/gm), *Pichia anomala* (2.0×10^6-7.2×10^7/gm), *Mucor circinelloides* (1.0×10^6- 4.1×10^7/gm) and *Rhizopus chinensis* (<10-1.0×10^6/gm). Among the moulds, *S. fibuligera* has amylolytic activity[19].

Balam

The beverage *jann* and *daru* are prepared using starter material called as *balam* in Kumaon and *balma* in Garhwal region of Uttaranchal[3]. It is made up of wheat flour, clove (*Cinnamomum zeylanicum* Nees), *elaichi* (*Amomum subulatum* Roxb.), *kalimirch* (*Piper longum* L.), leaves of wild chillies and seeds of pipal (*Ficus religiosa* L.). In addition, old *balam* is also mixed. The mixture is prepared with required amount

of water and made into a thick paste. This mixture is pressed between palms to make *balam* balls of the required size. These are dried in shade and stored for future use[3].

Ranu dabai

It is used in the preparation of the beverage *jhara* as a source of starter culture[20]. During the preparation of *ranu dabai*, rice is washed with clean water and the decanted water is stored. All the fresh plant materials (Table 1) are chopped, ground properly along with rice and old *ranu dabai* by using traditional wooden husking machine called *Dhiki*. These are made into paste using the decanted rice wash water. Clean gunny bags are spread on the floor under shade or inside of the rooms. The prepared paste is made into tablets by hands without using any die. The tablets are arranged in rows on the gunny bags, where these are kept for 40-60 min. After slight drying, the tablets are arranged into a row in the large bamboo basket. Then, these are covered by straw and another layer of tablet is kept on it. This process is repeated until the basket is filled. Finally, a large amount of straw is added at the top. The entire set is covered by polythene sheets and/or gunny bags and stored in a dark warm place for 2-3 days. During this period, a layer of fungal mycelia develops on the tablets. Afterwards, tablets are dried in the sun for 7-8 days and stored for future use[20].

Indigenous fermented beverages

In western countries, various types of beverages are prepared using barley malt, as a source of starch and saccharifying agent. In contrast, ragi, rice and barley are used as starch and saccharifying agent in the preparation of Indian traditional beverages[21]. A number of alcoholic beverages are prepared and consumed by indigenous people of India.

Soor

It is a type of alcoholic beverage prepared during rough weather and during festival seasons by the Himalayan traditional people[18]. It is prepared using starter material called *keem*. Apple, pears, peach, apricot, rice, barley or finger millet are used as raw materials for the preparation of *soor*, which contains 35-40 % alcohol[18].

Jhara

The rice beer called *jhara* is extremely popular among the tribal inhabitants of West Bengal[20]. During the preparation of *jhara*, various herbal plants and their parts are used to produce sweetness, bitter taste, colour and also act as preservative. *Ranu dabai* is used as a starter material for the preparation of *jhara*. The fermented liquid is diluted with drinking water at the rate of 5 l/ kg of rice and consumed.

Tchang /Jhar and Rokshi

The tribal people of Sikkim consume beverages called *tchang*/*jhar* and *rokshi*, in which *tchang* is prepared using millet (*Paspalum* sp.) and *rokshi* is prepared using certain plants and plant parts[22, 23].The fermented millet is transferred into bamboo or wooden cylindrical cups. Lukewarm water is poured inside the cups and drunk by suction through a small pipe of bamboo. It can be repeated until the flavour is available. *Canna edulis* Ker Gawl. and *Zea mays* L. are the important plants used in the preparation of *rokshi* by the ethnic people of Sikkim namely *Lepcha*, *Bhutia* and *Nepali*[23]. *Jhar* and *rokshi* samples contain filamentous moulds and yeasts (*Mucor cicinelloides*, *Rhizopus chinensis*, *R. stolonifer* var. *lyococcus*, *Saccharomycopsis fibuligera*, *Saccharomyces cerevisiae*, *Hansenula anomala*, *Pediococcus pentosaceus* and *Lactobacillus* sp.).

Ghanti, Jann* and *Daru

The people in Kinnaur district of Himachal Pradesh consume *ghanti*, which is made from fermented musk and *Bhotiyas* of Uttaranchal consume *jann* and *daru*, *which* are prepared from cereals and fruits[3]. The people of Indian trans Himalayan region such as Ladakh and Lahaul–spiti, call *Ghanti* as *chang*. *Jann* is a traditional local drink of *Bhotiyas* of Uttaranchal. It contains very low concentration of alcohol. It is prepared from rice (*Oriza sativa* L.), *koni* [*Setaria italica* (L.) P. Beauv.], wheat (*Triticum aestivum* L.), *jau* (*Hordeum vulgare* L.), *oowa* (*Hordeum himalayense* Schult.), *chuwa* (*Amaranthus paniculatus* Wall.) and *china* (*Panicum miliaceum* L.). Similarly, among the fruits, apple is most desired. But *jann* prepared from *koni* is considered to be the best in quality. After fermentation, the *jann* is filtered through sieves and the resulting filtrate is consumed. *Jann* is also prepared from fruits of banana, pumpkin and orange.

Daru is a distilled liquor containing ethyl alcohol at a much higher concentration. Rice, *jaggery*, *koni*, *chuwa*, *oowa* and wheat are used in the preparation of *daru*. *Jann* and *daru* are prepared by anaerobic fermentation. *Jann* is obtained by slow fermentation

Table 1— Properties of the herbal plant parts used in the preparation of *Ranu dabai*

Plant name	Plant part	Usage
Coccinia grandis L.	Tuberous root	Develops sweetness
Vernonia cinerea L.	Whole plant	Produces sweetness
Clerodendrum viscosum Ventenat	Terminal and soft leaves	Produces bitterness
Plumbago zeylanica L.	Leafy branches	Process enhancer
Stephania japonica (Thunb.) Miers	Tuberous root	Preservative
Stephania glabra (Roxb.) Miers	Tuberous root	Preservative
Oroxylum indicum L	Bark	Imports bitter taste
Mussaenda roxburghii Hook.f.	Root	Develops sweetness and yellowish tint in liquor
Scoparia dulcis L.	Leafy twigs	Improves sweetness
Rauvolfia serpentina L	Root bark	Develops bitterness
Artocarpus heterophyllus Lam.	Leaves	Improves sweetness and yellowish tint in liquor
Wattakaka volubilis (L.f) Benth	Stem bark	Develops bitterness

consuming a period of 6-10 months in porous earthenware at a temperature of 10-15ºC. But *daru* is obtained by a rapid fermentation within a period of 2-3 days. It is performed in a non-porous metallic ware at a temperature of 30-40ºC.

Palm wine or *toddy*

Varieties of palm wines or *toddy* are consumed all over the world[6]. In India, the fermented palm sap is known as *toddy* or *kallu.* The *toddy* is prepared from coconut palm (*Cocos nucifera* L.). Generally, palm wines are popular beverage among the low-income people. Palm wines are prepared wherever the palm trees are grown. Fresh palm sap is generally a dirty brown, but it becomes pale and eventually milky white and opalescent if yeasts multiply. Thus, palm wine is generally sweetish, heavy, milky, vigorously effervescent alcoholic beverage. The alcohol content of palm wine is 1.5-2.1% during consumption. Faint sulfur like odour may also be present. Palm wine is consumed as a mildly alcoholic beverage similar to beer. Palm wine has a special place in traditional celebrations and ceremonies such as marriages, burials, and settlings. *Toddy* is believed to be good for the health particularly for eyesight and also serves as a sedative. It is also a mild laxative relieving constipation. It is prescribed as a tonic for those recovering from diseases such as chicken box[6].

The palm wine fermentation is always a lactic alcoholic acetic one, involving lactic acid bacteria, yeast and acetic acid bacteria as well as *Leuconostoc* sp. and *Zymomonas* sp. *Leuconostoc* sp. and *Lactobacillus* sp are early bacterial inhabitants of the palm sap[6]. *Saccharomyces cerevisiae* carries out the alcohol fermentation. The main ingredient of the fresh sap is sucrose (12-15% by weight). There is very little reducing sugar, although glucose, fructose, maltose and raffinose are present. In addition to sugar, the sap also contains 0.23% protein, 0.02% fat, mineral matter and ascorbic acid (5.7mg/100ml). During the first 24 hrs fermentation, more than half of the total sugars are fermented. Sucrose is always used rapidly. Acetic and lactic acids are produced along with ethanol during fermentation. After about 36-48 hrs, the concentration of ethanol reaches a maximum of 5.0-5.28 % v/v; the concentration of ethanol soon starts to fall if the palm wine is stored for a long period. The *p*H of the original palm sap is about 7.2 and after 8 hrs it falls to 5.5-5.8[6].

Jackfruit wine

It is an alcoholic beverage made by fermentation of jackfruit (*Artocarpus heterophyllus* Lam.) pulp[24]. It is a social and tribal beverage and has characteristic pungent aroma and flavour. The tribal people of Nagaland, Tripura and other eastern hilly areas of India consume jackfruit wine. The wine contains7-8% v/v alcohol[24]. A pungent aroma that increases during storage due to side reactions masks the quality of product. Yeast resembling *Endomycopsis* is

involved in the fermentation process of Jackfruit wine.

Zutho

For the preparation of zutho, unhulled rice grains and polished rice grains are used for fermentation[21]. The resulting drink is called zutseh, a strong beverage. For zutho, some amount of water is added in zutseh for dilution. In zutho fermentation, Saccharomyces cerevisiae is the dominant microflora; in addition, Rhizopus sp. is also involved in the process[21].

Fenny

It is a type of distilled alcoholic beverage, which is made from coconuts or from fruit pulp of cashew (*Anacardium occidentale* L.). It is registered as a Geographical Indication (GI). Cashew *fenny* is unique to Goa[25]. In most of the country distilleries, the pungent cashew apples are crushed in a large rock hollows using large boulders and such like or cashew apples are foot trodden and then fermented. Traditionally, the cashew juice is fermented by itself. After three days of fermentation, the product is triple distilled. The first distillation produces arrack, and second distillation produces cashew *fenny*, very rarely third distillation produces very potent cashew *fenny*. Afterwards, the high alcohol content is reduced with spring water to bring it to 40-45% alcohol per volume[26]. Coconut *fenny* is a distilled product from coconut *toddy*.

Dye yielding traditional fermentations

Various types of natural dyes and adhesives for dyeing are prepared through traditional fermentation by *Meitei*, ethnic people of Manipur[27,28]. These natural dyes, as listed below, are obtained from plants and their parts. They are used for colouring clothes, bamboo baskets, flowers pots, fishing nets, etc.

Psidium guajava L.: An adhesive for black and brown colour is obtained from fresh and mature fruits[27].

Strobilanthes cusia (Nees) Imlay.: A traditional process with the addition of ashes of oysters decays mature leaves. The liquid (*kum*) obtained is used for dyeing clothes or threads[27]. Brilliant blue and black dyes are obtained from this plant by various procedures including fermentation. Dyes extracted from this plant are most popularly used for dyeing of costly loin clothes of the womenfolk of the state[28].

Carthamus tinctorius L.: The fresh petals of *C. tinctorius*, leaves of *Stachyphrynium imbricatum* (Roxb.) K.Schum. and *Achyranthes aspera* L. are processed including fermentation to obtain yellow, golden yellow and pink dyes[28]. These dyes are used for dyeing cotton and silk clothes and also in painting[28].

Emblica officinalis Gaertn. : Crushed fruits/bark or both are used for obtaining an adhesive for dyeing dark colour[27]. In addition, a reddish black dye is also obtained. They are used for colouring the fishing nets[28].

Parkia roxburghii G. Don: Fruit skin is subjected to fermentation to obtain a dark brown colour, which is used as adhesive for different dyes especially for red colour[27].

Osbeckia chinensis L.: Fruits are used to obtain a violet dye. This dye is used in olden days for colouring teeth[28].

Zizania caduciflora Hand- Mazz.: A black dye is obtained from the culms infected by a fungus *Melanopsichium esculentum* P. Hen. The dye is used for dyeing and painting[28].

Therapeutic application of traditional fermented products

The traditional fermented products also have therapeutic properties. The traditional fermented product, *wheyghurt* drink is used to treat various illnesses in human beings, viz. gastrointestinal disorder, hypercholesterolemia, tumours, and protein allerogencity, etc[29]. Small amount of *rokshi* is given to children for alleviating cold and cough[23]. Some group of wines or alcoholic beverages were prepared and consumed to treat illness of man since the *Vedic* period[30]. They were classified into *sura, gauda, sarkara* and were used to treat obesity, dropsy and also for nourishment. In the ancient times, the practice of surgery is said to be performed using special liquors as anasthesia[31]. The use of liquors as an anesthetic media has been referred to in the ancient treatises on medicine. These liquors were extracted from fruits, sugarcane and even some types of roots. Such liquors were consumed in normal times apart from medical usage.

Traditional usages of mushrooms for therapy

The pink oyster mushroom, *Pleurotus eous* Sacc., is given to the patients convalescing from childbirth and fever[32]. *Termitomyces heimii* Natarajan, a common edible mushroom is recommended for nourishing mothers[32]. The edible mushrooms are

collected from the forest and consumed by the tribal people as a substitute for vegetables. *Copelandia cyanescens* is a common psychoactive mushroom, which is isolated from the cattle dung[32]. In addition, few species of *Amanita muscaria* is also recommended as psychoactive mushrooms[32]. There is a hypothesis in *Ramayana* that the decoction of luminescent mushroom *Omphalotus olearius* is administrated to cure of poisoning. This type of practice, using one type of poison to cure another poison is quite common in traditional Asian Medicinal Systems[32].

Other applications of traditional fermentations

Fermented food as a source of valuable enzyme producing microorganisms

Valuable enzyme producing microorganisms are also isolated from the traditional fermented foods. Amylase and glucoamylase producing microorganisms such as *Rhizopus stolonifer, Saccharomycopsis fibuligera* and *Pichia anomala* were isolated from the *marcha*, a traditional fermented food[33]. The traditional fermentation leads to the discovery of new source for isolation of phytate hydrolyzing microorganisms. They are isolated from the traditional *kooradu* fermentation and *kudithi* liquid cattle feed. Bacteria belonging to *Serratia* sp., *Staphylococcus* sp. and *Streptococcus* sp. are predominant in the *kali* (fermented waste water of rice) sample, but *Bacillus* sp. and *Pseudomonas* sp. are abundant in *kudithi* sample. In addition, *Saccharomyces cerevisiae* is present in the *kudithi* samples and *Lactobacillus* sp. is also observed in the *kali* samples[34].

Biopreservation of foods

During fermentation of traditional food, the bacterial genera namely *Lactobacillus* sp. and *Pediococcus* sp. produce organic acids such as lactic acid and acetic acid which reduce the *p*H, thereby inhibiting the growth of food spoiling microorganisms[35]. These fermented foods can be preserved for several days without refrigeration and addition of synthetic preservatives.This type of traditional method is followed by indigenous people of eastern Himalaya for the preservation of vegetables[35]. The microorganisms responsible for the production of fermented food also exhibit antibacterial activity. Inhibition of *Salmonella typhimurium* and *E. coli* by fermented flour of finger millet has been documented[36]. During production of *dahi*, the microorganisms produce organic acids such as lactic acid, acetic acid, etc. In addition, metabolites such as lactocidin, niscin and acidophilin are also produced which exhibit antibacterial property[6].

Ingredient in fish attractant

The tribal people of Karbi-Anglong district in Assam use a rice beer mixture to catch fish[37].

Animal feed

The residue from the *soor* fermentation is used as a highly nutritive feed to cattle[18]. Similarly, the residues from *tchang / jhar* and *rokshi* beer are also used as feed for pig[22, 23]. *Kooradu* contains fermented wastewater of rice called *kali*. The cattle consume it as a good source of vitamin and enzymes and *kudithi* also used as cattle liquid feed in the rural areas of Andhra Pradesh [34].

Patent analysis for traditional products of microbial origin

In order to find out the scope for IPR protection, patent analysis was made in the available databases using search keywords. All the products discussed above were used as search keywords. The analysis was made in Ekaswa A (which comprises patents applications filed in India from January 1995 to December 2003) and Ekaswa B (which covers patent application notified in India from January 1995 to March 2004) databases and CSIR database as available in patestate web site (www.patestate.com). In both Ekaswa A and B, the search was based on the title and abstract. Ekaswa A indicated filing of patents in products like *idli, kinema* and *toddy* (Table 2). But only 4 entries are available. Ekaswa B database indicate notification of patents in *idli* (patent number. 187818). A similar analysis in patestate database showed the presence of a single patent in *idli* preparation (patent number 192486, An improved process for the preparation of *idli* batter having increased shelf life) and another patent on the preparation of cereal lassi concentrate exploiting certain microbes (patent number 173627). Apart from these two, other relevant hits could not be obtained.

Analysis in USPTO database was made which facilitates full text search since 1976 to date. It indicated several hits, but a few are relevant. There are two patents in *dahi*, where the relevance of knowledge from Indian *dahi* preparation was indicated (patent number 3,985,901, preparation of

Table 2— Patents filed related to traditional fermentation as per Ekaswa A

Title	Application Number
A process for preparation of fermented and dehydrated batter useful for making Indian traditional products *idli*, *dosa* and like.	350/DEL/2002
A process for microbial fermentation of *idli* dry mix.	2506/MAS/98
A process for producing *kinema* using a pure starter culture.	100/KOL/03
Cassia fistula Linn. seeds and seed powder for selective inhibition of spoilage bacteria in coconut *toddy* while permitting the ongoing fermentation toddy into wine.	635/MAS/95

acidophil milk in powder form; patent number 5,453,286, Method for converting milk into fermented milk). One more patent hit is about the preparation of fermented herbal health drink using the plant *Andrographis* (patent number 6616950, Fermented herbal health drink from plant *Andrographis*). Patent search was also made in JPO, where patent titles and abstracts are available for access, but there was no patents related to Indian traditional fermented foods. In EPO database, which provides the title of the patent, could also indicate the lack of patents in Indian traditional fermented foods. Searching of patents in WIPO (PCT) (www.wipo.int/ipdl/en/search-adv.jsp#) also provided negative results.

So the trends in IPR analysis indicated that there are scanty numbers of patents in Indian traditional microbial products in India and elsewhere. This further indicates that there is an extensive scope to investigate such kind of knowledge so as to end with the development of traditional products on the basis of IPR legal framework ensuring benefit sharing with indigenous people.

Conclusion

A perusal of development in the traditional knowledge systems in India thus amply demonstrated that the rural folk of our country are exploiting microorganisms unknowingly. It is now well known that a variety of cereals, pulses and milk based fermented food products are prepared by them. Better utilization and preservation of vegetables and fish foods are achieved exploiting microbes. They are competent in making diverse beverages, which also support their health. Astonishingly, they prepare microbial culture starter for use as inoculum in the beverage production. The art of making culture starter is based on the principles of microbiology and much is based on the preservation of desired microorganisms in encapsulated forms. It is also exciting to know that our people are aware of getting dyes using microbial processes. They have used mushrooms for therapy. Such potential knowledge from indigenous people can definitely find due market value. In the IPR front also, not extensively, patents are availed in traditional knowledge of microbes from India. So, it is evident that research in various dimensions particularly on microbial systems involved in these products along with characterization and improvement are possible with the application of modern tools of science.

In the Indian context, the states in the North East India have the richest reserve of traditional knowledge due to their hilly nature where harsh conditions normally prevail. The major contributors of this knowledge are tribal people naturally living in such hills. This kind of trends could not be seen in plains due to various reasons including urbanization. So, there is a gradual loss of traditional knowledge. It is thus necessary to work with indigenous people, local communities, tribal people, etc. to explore such information and protect them by legal tools like IPR with benefit sharing and avoiding biopiracy[4,5]. Moreover, exploitation of traditional knowledge in microbes may not lead to the destruction or eradication of biodiversity as in the case of plants and animals since microorganisms can be easily cultured by artificial means and hence there is no thread of depletion of microbial biomass as happening with plants and animals in nature.

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