

REVIEW PAPER

Indigenous Fermented Foods of India with Special Reference to Andhra Pradesh and Adjoining Areas

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ABSTRACT

Indigenous or traditional fermented foods have been prepared and consumed world over including South Asia for hundreds of years and are strongly linked to cultures and traditions of millions of people around the world, especially in rural communities. A food is considered fermented when one or more of its constituents have been acted upon by selected microorganisms or their enzymes to produce a significantly altered final product desirable for human consumption. Most fermentations are caused by molds, yeasts, or bacteria, either singularly or in combination. The origins of most fermentation technologies have been lost in the mists of history. Some products and practices no doubt fell by the wayside; those that remain today have survived the test of time. Indigenous Fermented food products are important components of the diet as staples, adjuncts to staples, condiments, and beverages. There is a need to protect our traditional technology and foods that are very valuable. In this review we have given a brief account on traditional/indigenous fermented foods (preparation methods, microbes involved, biochemical changes and preservation techniques) especially of Andhra Pradesh (AP), India.

Keywords: Fermented foods, olds, yeasts, bacteria, traditional technology

Traditional foods are generally categorized into fermented foods and non-fermented food. Fermented foods are prepared by the action of microorganism(s), either naturally or adding starter culture (s), which modify the substrates biochemically and organoleptically into edible product, and are thus, generally palatable, safe and nutritious (Pederson, 1960; Tamang and Holzapfel, 1999; Hansen, 2002; Campbell-Platt, 1987; Achaya, 1998; Joshi, 2016; Molinos *et al.* 2016). These inexpensive culturally acceptable traditional foods provide basic diet as staple, pickle, confectionery, condiment and alcoholic beverages, which supplement enhanced nutrition, palatability, wholesomeness of the product with acceptable flavor and texture (Steinkraus, 1967;

Joshi, 2012). Most of them are common while other fermented foods are less familiar and confined to particular community and places. For food fermentations by molds, yeasts, or bacteria, either singularly or in combination are used. Indigenous or traditional fermented foods have been prepared and consumed by the people around the world, especially in rural communities. The origins of most fermentation technologies have been lost in the mists of history. Some products and practices no doubt fell by the wayside; those that remain today have survived the test of time. Fermented food products

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are important components of the diet as staples, adjuncts to staples, condiments, and beverages.

FERMENTED FOODS

A food is considered fermented when one or more of its constituents have been acted upon by selected microorganisms or their enzymes to produce a significantly altered final product desirable for human consumption. This oldest form of food biotechnology originated as a necessity for enhancing the keeping quality of diverse plant and animal food materials through organic acid, alcoholic, and alkaline fermentations. Fermentation, a relatively efficient low-energy preservation process, also improves digestibility, flavor, appearance, nutrient contents, and other quality attributes and reduces antinutritional components of the substrates and cooking time (Nouts, 2001). Many fermented foods are now receiving global attention for their health-promoting or disease-preventing or -curing effects. Whereas a considerable number of food fermentation processes have been scaled up for commercial purposes, most types of fermented foods are still produced on a home scale. Such products often contain mixed genera and populations of microorganisms because of the lack of controlled processing facilities. In view of larger-scale industrialized food fermentation, microbial ecology and metabolic activities of functional microorganisms must be investigated. Present-day developments in molecular methods enable accurate characterization of strains and development of tailor-made fermented food products (Adams 1999).

Three major types of microorganisms are associated with traditional fermented foods and beverages (Ray and Joshi (2014) and these are:

Microorganisms associated with fermented foods

- ❑ **Filamentous fungi:** Species of *Aspergillus*, *Amylomyces*, *Aciinomucor*, *Monascus*, *Mucor*, *Neurospora*, *Penicillium* and *Rhizopus*.
- ❑ **Yeasts:** Species of *Candida*, *Debaryomyces*, *Georichum*, *Hansenula*, *Kluyveromyces*, *Pichia*, *Saccharomyces*, *Saccharomycopsis*, *Torulopsis* and *Zygosaccharomyces*.
- ❑ **Bacteria:** Species of lactic acid bacteria

(LAB)- *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Enterococcus*, *Pediococcus*, *Tetragenococcus* and *Streptococcus*, Species of *Acetobacter*, *Citrobacter*, *Klebsiella*, *Bacillus*, *Brevibacterium* and *Propionibacterium*.

Types of Fermented foods

A variety of fermented foods can be found widespread over the world and the foods are prepared in India are presented in Table 1, some of them, made in Andhra Pradesh are described in this review. Indigenous fermented foods can be divided into the following types depending up on the substrate used:

- ❑ Fermented milk products
- ❑ Fermented cereal-legume/legume based products
- ❑ Fermented cereal foods
- ❑ Fermented vegetables and fruits
- ❑ Fermented beverages

FERMENTED MILK PRODUCTS

Fermented milk products have nutritive and medicinal value. Being tropical region in the south India, the sour milk preparation started ages ago because of that it is more stable and contain high quality nutrients compared to the fresh milk (Mann 1977).

Dahi/Curd

This is one of the most popular and oldest Indian fermented milk products, known for its milk acidic taste and pleasant flavour and is equivalent to western yogurt (Laxminarayana and Shankar, 1980). The Aryans made a virtue of it so much so that it is must in the Indian daily menu. Curd is said to create relish for food, promote appetite, operate as emollient and increase strength. A good quality *dahi* is firm and of uniform consistency with sweet flavor and acidic taste. The surface is smooth and glossy and usually a cut surface is trim ad free from cracks and gas bubbles.

Preparation of curd/*dahi* is probably originated for the preservation of surplus milk. The inocula

Table 1: Common traditional fermented foods/beverages of India

Food	Substrate	Microorganism	Nature and use
Traditional Fermented Products of South India			
<i>Ildi</i>	Rice-black gram	LAB, yeasts	Steamed, spongy cake; breakfast food
<i>Dosa</i>	Rice-black gram	LAB, yeasts	Spongy pan cake, shallow fried staple food
<i>Dahi</i>	Milk	<i>B. amyloliquefaciens</i>	Sweet/sour beverage use to take along with rice
<i>Butter milk</i>		LAB	
<i>Lassi</i>		LAB, <i>Bacillus</i> spp.	
<i>Ambali</i>	Millet, rice	LAB, yeast and <i>Bacillus</i> spp	Sweet and flavoured beverage
<i>Kanji</i>	Carrot or beet roots	LAB, yeast and <i>Bacillus</i> spp	Steamed sour cake, staple food
<i>Kali</i>	Black gram	Starter culture used is TORANI	Strong flavored alcoholic beverage's
<i>Papadam</i>		Which contains LAB, Yeasts	
<i>Pickles</i>			
<i>Toddy/Palm wine</i>	Matured fruits and vegetables	LAB	
<i>Sara</i>	Sap from inflorescence/trunk of palm plants	LAB, Yeasts	
	Black jiggery and plant bark	Yeast, LAB and <i>Acetobacter</i>	
Traditional fermented products of North India			
<i>Ballac</i>	Black gram	LAB, Yeasts, <i>B. subtilis</i>	Deep fried patties, snack
<i>Vadai</i>	Black gram	LAB, Yeasts, <i>B. subtilis</i>	Deep fried patties, snacks
<i>Papad wari</i>	Black gram	LAB, Yeasts.	Circular wafers, snacks
<i>Bhatura</i>	Black gram	LAB, Yeasts.	Ball like hollow, brittle, condiment
<i>Nan</i>	Wheat	LAB	Flat deep fried, leavened bread, snack
<i>Jalebi</i>	Wheat	Yeasts, LAB	Leavened flat baked bread, staple food
<i>Paneer</i>	Wheat	LAB, Yeasts	Crispy, deep fried, pretzel sweet confectionery.
	Milk	LAB	Soft mild flavored cheese, fried, curry
Traditional fermented products of western regions of a India			
<i>Dkokla</i>	Bengal gram	LAB, yeasts	Steamed, spongy cake; snack
<i>Khamam</i>	Bengal gram	LAB	Spongy cake; breakfast food
<i>Rabadi</i>	Wheat/pear-millet/ maize/ barley buttermilk mixture	LAB, <i>Bacillus</i> spp.	Cooked paste; staple food
<i>Sl,rikjrand</i>	Milk	LAB	Concentrated sweetened, savory
Traditional Fermented Products of Eastern Regions of India			
<i>Mistidalji</i>	Milk	LAB	Thick gel, sweet savory
<i>Tari</i>	Datepalm	Yeasts, LAB	Sweet cloudy white alcoholic beverage

Traditional Fermented Products of the Himalaya			
<i>Kinema</i>	Soybeans	<i>Bacillus subtilis</i> , <i>Enterococcus faecium</i> , yeasts	Sticky with typical flavor; side-dish curry
<i>Hawaijar</i>	Soybeans	<i>Bacillus spp.</i>	-do- Fish substitute
<i>Gundruk</i>	Leafy vegetables	LAB	Sun-dried, sour-acidic taste; soup/pickle
<i>Sinki</i>	Radish tap root	LAB	-do-
<i>Mesu</i>	Bamboo shoot	LAB	Sour-acidic pickle
<i>Laanr</i>	Finger-millet/rice maize/ barley	Starter culture used is <i>Mrrcha</i> which contains Filamentous moulds, Yeasts, LAB	Mild alcoholic, slightly sweet-acidic beverage

Source: Soni and Sandhu 1986.

used in preparation are mixture of *Lactobacillus* and *Streptococci* spp. Generally, a small quantity of the curd from previous fermentation is used as inoculum. Acceptable quality *dahi* could be obtained with the application of acid producing as well as flavor (primarily diacetyl)-producing micro-organisms and adopting two-stage fermentation. Biotechnological innovations suggest inclusion of certain probiotic and beneficial bacteria for further enhancement in the dietetic properties of traditional *dahi*. Application of bio-preservatives and thermization (mild heat-treatment) may be recommended for shelf-life extension of *dahi* to extend the market reach (Gandhi, 1989). The commonly associated lactic microflora in the inoculum are *Lactobacillus lactis*, *Lactobacillus delbrueckii*, *L. acidophilus*, *L. helveticus* and *S. thermophilus*. Extensive research is carried out in NDRI (Karnal and Bangalore) covering important aspects such as determining lactic microflora in homemade and commercial samples; isolation of lactic culture from *dahi* and suitability of lactic culture in getting stable product of acceptable quality attributes; good quality; biochemical and microbiological changes occurring during fermentation (Sreenivasan and Benarjee, 1946; Laxminarayana *et al.* 1952; Attaie *et al.* 1987; Gandhi, 2002). Composition and quality of *dahi* vary widely from one locality to another as it is being prepared under different market and domestic conditions as well as types of milk, with variable chemical and bacteriological quality used for the preparation. However, the chemical composition of *dahi* has been reported as fat ranging from 5-9%, protein 3.3-3.4%, lactic acid 0.5-1.1%, calcium 0.12-0.14% and ash 0.75 – 0.79%

Butter

Butter is one of the important fermented dairy products, although little is consumed directly (Rangappa and Achaya, 1974). It is used in small quantities as table butter and the rest of the major portion is used in the preparation of *ghee* and clarified butterfat. From the fresh milk first curd is prepared and then, the curd is churned with wooden or metal churns, during which butter rises to the top and is removed. Unlike the trained west farmer, the Indian farmer knowledge is purely traditional and handed down from the ancient times like Vedas. After the cooperative movement in Gujarat, now the butter is preparing in many dairy farms in large quantities commercially. Most predominant microorganisms that are present in butter are *Lactobacilli* followed by *Streptococci*, *Coli-forms* and aerobic spore formers. Yeasts and moulds also present in considerable number and contribute to acidity, colours and off-flavor. *S.lactis* subssp *diacetylactis* produces the flavor compounds diacetyl, acetaldehyde, acetoin and carbon dioxide (Gandhi 1989). Butter has moisture content of 18-20%, fat 78-81%, non-fatty solids 0.7-1.5%, acidity 0.5-0.8% (as lactic acid), energy 680-760 Kcal, Ca 400mg, Mg 30mg, Fe 0-15 mg, riboflavin 0.5 mg, thiamine 0.1 mg and niacin 2.5 mg.

Ghee

It is the Indian name for clarified butter fat and is mainly prepared from cow, buffalo, sheep or goat's milk. There is no cold storage for this and it has good shelf-life. It is prepared by heating the butter

or churned curd at 100-140°C for 5-10 min, which removes the water through evaporation. Then, is clarified using muslin cloth and cooled to solidify.

Ghee prepared from buffalo's milk has white colour but due to the presence of carotinoids *ghee* prepared from cow's milk is yellow in colour. All the microorganisms present in curd and butter are killed during heating process. So the *ghee* is free of microorganisms (Campbell-Platt 1987; Aneja 2002). *Ghee* contains water 0.1-1%, protein 0.5-1 g, ash 1-2 g, energy 880 Kcal, Na 100 mg, K 20 mg, Ca 20 mg, Mg 2 mg, P 30 mg, S 10 mg, Niacin 0.2 mg, retinol 900 ug, carotene 550 ug and vitamin E 1.8 ug (Campbell-Platt 1987; Aneja 2002).

Lassi

It is also a popular fermented beverage made in India. *Lassi* is appreciated throughout the country as a beverage for its palatability and as thirst quenching/refreshing drink. It is also known for its therapeutic values. The palatability and wholesomeness of the product depend on the quality of curd churned and temperature of churning. An average curd obtained by fermentation with contaminants produces a highly sour or off-flavored *lassi*, unfit for human consumption (Gandhi, 2002). In general, the preparation of *lassi* there are few steps such as:

- ❑ Add a little quantity of water to well set-curd in a container,
- ❑ Addition of water will depend on the composition of curd.
- ❑ Homogenize the contents using curd beater,
- ❑ Dilute the contents with 1-2 parts of cold water
- ❑ Add sugar at the rate of 14 to 20 per cent or add 1-2 per cent powdered common salt and mix the content.

The commonly associated lactic microflora in *lassi* include *Lactobacillus lactis*, *Lactobacillus delbruecki*, *L. acidophilus*, *Lueconostoc mesenteroides*, *L.diacetyllactis*, *L. helveticus* and *S. thermophilus*. To get good quality *lassi*, restricted fermentation with cultured

microorganisms produces *lassi* with byproducts such as enhanced acetaldehyde and diacetylyle (Gandhi, 1989). Composition of *lassi* vary widely with types of milk, with variable chemical and bacteriological quality used for the preparation.

Butter milk

It is a well known and highly consuming non-alcoholic dairy beverage in Andhra Pradesh and adjoining areas. Butter milk is prepared as homemade and commercial product as a by - product of butter making. Sometimes it contains small butter flakes (Lindsay *et al.* 1965). Because of its taste, nutrients and medicinal properties is a must with south Indian meal. It is prepared through natural fermentation of sour cream butter or from sweet and non-fermented cream. Traditionally it is prepared from churned *dahi*/curd by diluting with water (Sarkar *et al.* 1996). The commonly associated lactic microflora in buttermilk are *Lactobacillus lactis*, *Lactobacillus delbruecki*, *L. acidophilus*, *Lueconostoc mesenteroides*, *L.diacetyllactis*, *L. helveticus* and *S. thermophilus*. To get good quality buttermilk restricted fermentation with cultured microorganisms such as enhanced acetaldehyde and diacetylyle producing organisms are using. Generally the chemical composition of butter milk depends on *dahi* that used in preparation and large extent on butter making technology and season. It contains 9% dry matter, lactose 4%, lactic acid 0.5-1%, nitrogenous compounds 3.3-4%, ash 0.7% and fat content ranges from 0.3-0.6% (Agarwala and Sharma, 1961).

FERMENTED CEREAL AND LEGUME BASED PRODUCTS

Dosa/Dosai

Dosa is one of the very popular traditional fermented foods of South India. First reference to *dosa* occurs in Tamil Sangam literature from around 6th century AD and Chalukya king Somaesvara III describe the *dosa* in 1051. Eminent food scientist K.T. Achaya said that *dosa* have a history of two thousand years in Dravidian region (Achaya, 1998).

It is prepared from naturally fermented rice (*Oryza sativa*) and black gram (*Phaseolus mungo*) batter spreading 1:1 batter on a hot greasy griddle. More rice flour is used in *dosa* batter than idli batter. *Dosa* is prepared by the following steps:

- ❑ Soaking 3 parts rice and 1 part of black gram in water for 4-6h in ambient temperature 27-30 degree centigrade's,
- ❑ Grinding to a fine paste and mixing both to get a free running batter,
- ❑ 1% of salt is added to the batter and allowed to ferment overnight (10-16h). The natural microflora of both *rice* and *dhal* act as starter and bring about the fermentation.
- ❑ About 50-80 ml of batter is poured on to a hot, oiled pan and fried until crisp and brown colour on one side then turned to second side, cook well and rolled.
- ❑ This crispy and roasted *dosa* served with either coconut chutney or with lentil-vegetable curry (Soni *et al.* 1985).

Traditional *dosa* batter fermentation has revealed the occurrence and role of several bacteria alone or in combination with yeasts in bringing about various biochemical changes (Sandhu *et al.* 1986; Soni *et al.* 1986). *Leuconostoc mesenteroides*, *Streptococcus faecalis* and *Lactobacillus fermentum* are predominant among bacteria while *Saccharomyces cerevisiae*, *Debarvomvces hansenii*, *Trichosporon*, *Candida glabrata*, *C. tropicalis*, *C. sake*, *C. kruzsei*, *Hansenula* and *Trichosporon beigelii* are the common yeasts involved in fermentation. Microbes present in *dosa* batter and the microbes that contributed from two substrates are as shown in Table 2. *Dosa* fermentation is accompanied by an increase in total acids, total volume, total solids, soluble solids, non-protein nitrogen, free amino acids, amylases, proteinases, vitamins B1 and B2 (Soni *et al.* 1985; 1986; Sandhu *et al.* 1986). Total nitrogen and total proteins do not vary significantly where as reducing sugars and soluble proteins after declining initially tend to increase afterwards with the progress in fermentation. *Dosa* contains 35-40% water (on dry

matter basis), 15-20%, fat 15-25%, carbohydrates 40-50% fiber 5-8%, ash 4-6% and energy 400-450 Kcal, vitamin B, niacin, thiamine concentrations increased during fermentation (Soni *et al.* 1985).

Biochemical changes and Improvements

With the advent of fermentation acidity is increased and carbon dioxide is produced. The production of acid and gas in *dosa* and *idli* is dependent upon bacteria while the yeasts contribute enzymes and esters which impart desirable flavours (Radhakrishnamurthy *et al.* 1961; Steinkraus *et al.* 1967).

Table 2: Prevalence of different bacteria and yeasts in fermented *dosa* batter

Microorganism	No.	%
Bacteria		
<i>Leuconostoc mesenteroides</i>	33	94
<i>Streptococcus faecalis</i>	30	85
<i>Lactobacillus fermentum</i>	25	71
<i>Bacillus amyloliquefaciens</i>	20	57
<i>Lactobacillus delbrueckii</i>	13	37
<i>Bacilluspolymyxa</i>	5	14
<i>Pediococcus cerevisiae</i>	5	14
<i>Bacillus subtilis</i>	5	14
<i>Micrococcus varians</i>	3	8
<i>Enterobacter sp.</i>	3	8
Yeasts		
<i>Saccharomyces cerevisiae</i>	18	51
<i>Debaryomyces hansenii</i>	15	43
<i>Trichosporon beigeUii</i>	9	26
<i>Hansenula anomala</i>	6	17
<i>Torulopsis candida</i>	5	14
<i>Oosporidium margaritifarium</i>	4	11
<i>Candida robusta</i>	3	9
<i>Trichosporon pullulans</i>	2	6
<i>Kluyveromyces marxianus</i>	2	6
<i>Candida kefir</i>	2	6
<i>Candida krusei</i>	2	6
<i>Rhodotorula mucilagimosa</i>	1	3
<i>Rhodotorula glutinis</i>	1	3

Source: Soni and Sandhu 1986.

The biochemical and physiological characterization of the predominant microorganisms that yeasts *Saccharomyces*, *Debaryomyces*, *Trichosporon* and *Hansenula* help in the degradation of starch into

maltose and glucose by producing extracellular amylolytic enzymes which are utilized by developing microbial load. Bacteria along with some yeast are mainly responsible for the production of acid and gas from simple sugars like glucose and maltose and thus account for its fall in pH and rise in volume with the progress in fermentation. Some strains of *Saccharomyces cerevisiae* also produce acid and gas from starch itself and may thus play a major role in *dosa* fermentation. Due to the ability of some strains to grow at high temperature (42° C), *Saccharomyces* and *Trichosporon* along with bacteria also play a role in fermentation during summers when the temperature of the atmosphere exceeds 40°C.

Table 3: Volatile flavour compounds identified by GC-MS analysis in 2 day stored *Idli* batter cultures

No	Heterocyclic compounds	Retention time (Min)
1	Piperazinetrione	11.5
2	Benzitriazole	25.5
3	Imidazole	37.0
4	Cyclohexylamine	42.3
5	Chlorothiazide	46.0

Source: Renu Agarwal *et al.* 2000.

Further, it was observed in case of experimental fermentations carried out in our laboratory by self inoculating with different groups of micro-organisms that *Leuconostoc mesenteroides* and other acid producing bacteria mainly caused the acidification and leavening of the *dosa* batter while the yeasts *Saccharomyces cerevisiae* and *Debaryomyces hansenii* improved the nutritional quality of the batter in terms of flavour, total proteins, amino acids, vitamins and enzymes (unpublished data). According to Mukherjee *et al.* (1965), Steinkraus *et al.* (1967), the acid and gas required for souring and the leavening action in the *idli* batter are produced exclusively by the activity of hetero fermentative lactic acid bacteria *Leuconostoc mesenteroides* although there is a sequential change in the bacterial flora. Venkatasubbaiah *et al.* (1985) recently indicated that the gas production during *idli* batter fermentation depends upon the activity of the yeast flora belonging to *Hansenula anomala*, *Candida*

glabrata, *C. tropicalis*, *C. sake*, *C. kruzsei*, *Torulopsis candida*, *T. holmii* and *Trichosporon pullulans*.

The values of nutritional constituents and organoleptic characteristics of *dosa* reveal that the product is very nutritious. There are many ways to improve its physical and biochemical characteristics by replacing the black gram, rice and restricted fermentation using selected known microorganisms. Attempts have been made to prepare *dosa*-like products with the replacement of black gram with sorgam, maize and bajra (Ragavendra Rao *et al.* 1979; Soni and Sandhu 1990). Especially *S. cerevisiae* in combination with the natural bacterial flora can play a significant role in further improving the nutritional quality and acceptability of *dosa* (Soni *et al.* 1989a and b). Further, Soni *et al.* (1989b) studied the replacement of the legume component and fermentation and fermentation can be satisfactorily performed in *dosa* batter by choosing suitable proportions of the ingredients. Mung beans, for example, rich in soluble compounds, and soybeans rich in proteins and enzymes, and they stated that can be used in combination with black grams which impart attractive organoleptic characteristics for further improving the digestibility and nutritional value of traditional *dosa*.

Idli

Idli is a very popular traditional fermented breakfast food staple consumed in the Indian subcontinent, especially in southern parts (Joshi *et al.* 2011). The major ingredients are rice (*Oryza sativum*) and black gram (*Phaseolus mungo*). *Idli* (and the process of steaming) was known in Southern India by as early as 700 CE. The process of steaming was influenced from Indonesia subsequently between 800-1200 CE, giving rise to the modern day *Idli*. Traditional *Idli* preparation is depicted in Fig. 1, and briefly as follows: 1. Soaking the polished parboiled rice and decorticated black gram separately for 4 – 5h at 30 ± 1C in water. 2. After draining the water, grind the rice and black gram separately to 0.5- to 0.7-mm particle size batter with occasional addition of water during the grinding process. 3. Mixing rice and black gram

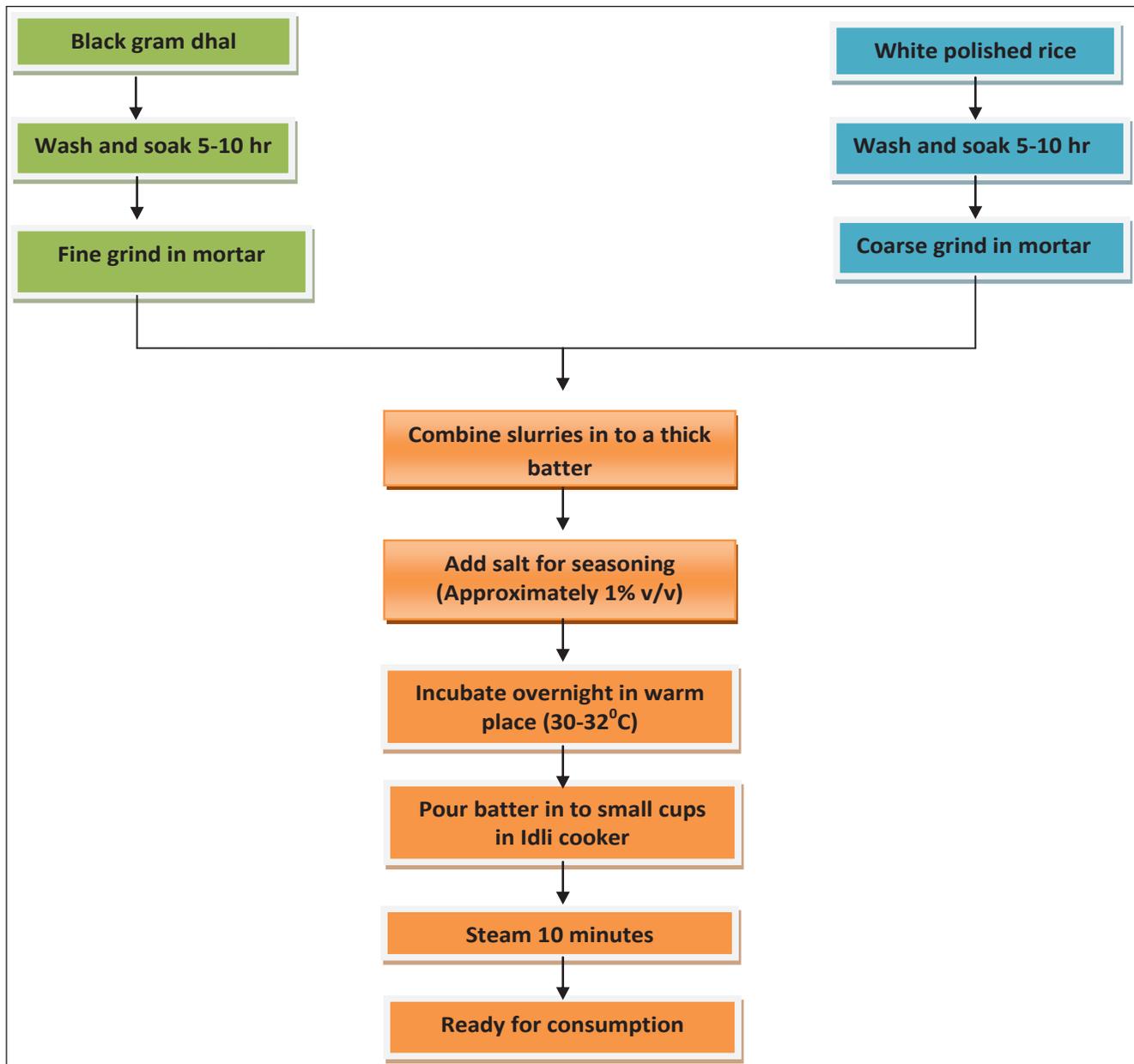


Fig. 1: Flow chart for *Idli* production

batters together in ratios of 2:1, 3:1 and 4:1 (v/v) batter were allowed for fermentation (0, 6, 12, 18 and 24 h) adding 2% of salt. 4. Allowing to ferment overnight at room temperature. 5. Depositing the fermented batter in special *Idli* pans and steaming for 5±8 min (Balasubramaniam *et al.* 2006). It may have been found that the rice helped speed the fermentation process. Although the ingredients used in preparing

idli have changed, the preparation process and the name have still remained the same.

The production of acid and gas in *idli* is dependent upon bacteria while the yeasts contribute enzymes and esters which impart desirable flavours (Radhakrishnamurthy *et al.* 1961; Steinkraus *et al.* 1967). The lactic acid bacteria *Leuconostoc mesenteroides*, *Streptococcus faecalis*, *Lactobacillus*

delbrueckii, *Lactobacillus fermenti*, *Lactobacillus lactis* and *Pediococcus cerevisiae*, *Pediococcus pentosaceus* have been found to be responsible for the fermentation process, although *L. mesenteroides* and *S. faecalis* are considered to be the microorganism essential for leavening of the *batter* and for acid production in *idli* (Purushothaman *et al.* 1993; Ramakrishnan 1993). Yeast fermentation occurs overnight by the joint action of *Torulopsis candida* (Saito) *Trichosporon pullulans* (Lindner). In large cities, baker's yeast is used. *Idli* batter fermentation has been the subject of many research investigations covering aspects of optimization of ingredients, microbiological, physico-chemical and nutritional (Steinkraus *et al.* 1967; Ramakrishnan 1979; Venkatasubbaiah *et al.* 1984; Thyagaraja *et al.* 1991 and 1992). Two significant changes occurring in *idli* batter fermentation are leavening and acidification. These two parameters have been used as the criteria for judging the progress of fermentation. The percent total acidity of *idli* batter at different period of fermentation ranged between 0.44 to 0.91% (Ghosh and Chattopadhyay, 2010). Black gram, the leguminous component of *idli* batter serves not only as an effective substrate but also provides the maximum number of microorganisms for fermentation. These levels have been reported as ideal parameters reached in 12±14 h of fermentation for obtaining acceptable products (Soni & Sandhu, 1990). In naturally fermented *batter*, within a period of 2 days, the pH and acidity levels were not organoleptically acceptable. The surface-active proteins and polysaccharides of black gram are well conditioned to retain a large volume of gases to give soft and fluffy texture.

Idli contains protein 14%, carbohydrates 35-50%, fat 0.2%, Ca 80 mg, Fe 3.5 mg. The vitamins content of *idli* batter per 100 g are 0.59 mg riboflavin, 0.59 mg thiamine and 0.76 mg folic acid and energy 65 Kcal/*idli*. It has also been reported that during fermentation, vitamins B and C increase, and also phytate is hydrolyzed almost to 50%. *L. mesenteroides* (leavening) and *S. faecalis* (acid production) develop concomitantly at soaking stage and continue to multiply following grinding (Mukherjee *et al.* 1965).

These changes during fermentation are highly significant for nutritional point of view. An increase in methionine, a limiting essential amino acid in legumes, greatly improves protein value.

Papadam

These are flat, spicy, circular wafers from South India. Prepared from flour paste of dehulled black gram and fermented 4 to 6- hours. These are thin, dried, crispy, circular tortilla like wafers made up of legumes, cereals or starch crop flour eaten as snake or with meal by deep fried or roasted (Sankaran 1998). The dough is prepared and rolled into wafers of around 10-20 cm in diameter and 0.5 mm thickness. These are then fermented and dried in open air for 4-6 h. Soni and Sandhu, (1990) isolated bacteria and yeast from papdams. There are three different types of bacteria present and *Leuconostoc mesenteroides* is the most common along with *Lactobacillus fermentum* and *S. faecalis*. Fermentation increase the soluble solids and decrease in reducing sugars. The batter amount increases with duration of the fermentation. It contains the PH 5, total acids 0.7%, total nitrogen is remain same, amylase is decrease and vitamin B1, B2 and B12 increased.

FERMENTED CEREAL FOODS

Ambali

Fermented product of South and East Indian cereal grass called *ragi* [*Eleusine coracana* (L.) Gaertn.] rice. In olden days it was taken as breakfast. People think this is very energetic and good for health. In villages of Andhra Pradesh people prefer this at working places where they need energy. Sometimes this takes with butter milk, green chilli, onions and pickles which give better taste (Ramakrishnan, 1979). *Ragi* flour is made into a thick batter with water and allowed to ferment for 14 hours. The fermented *ragi* batter is then added to cooked rice while stirring to avoid lump formation. It is allowed to cool, mixed with sour buttermilk, and consumed. The microorganisms are *Leuconostoc mesenteroides* (Tsenk.) V. Tieghem, *Lactobaci fermentum* Beij., *Streptococcus faecalis* and

Saccharomyces sp. The pH usually decreases from 6.4 to 4.0 and volume increases by about 20%, indicating CO₂ production (Ramakrishnan, 1979).

Kali

It is one of the indigenous fermented rice products in AP, India. To leftover cooked rice, water is added, and the mixture is allowed to ferment overnight. This generally prepare in summer season because of the high temperatures in the nights. People in AP believes that Kali cools the body and very good for health (Sekar and Muniyappa, 2007). The microorganisms are *Leuconostoc mesenteroides*, *Lactobaci fermentum* Beij. Yeast such as *Hansnula*, *Candida*, *Saccharomyces* sp.

FERMENTED FRUITS AND VEGETABLES

Pickles

Pickling is one of the oldest methods of food preservation. Pickles are one of the important consumer products (Joshi *et al.* 2013). The important pickles in India are mango, drumstick, brinjal, gongura, mirchi pickle, chicken pickle, mutton pickle, fish pickle and prawn pickle. Pickles are one of the earliest commercial products appeared in the market (Verma and Joshi, 2000). In Orissa and Andhra Pradesh, the people are consuming the various pickles in daily diet. Pickles are consumed along with staple food such as rice, *chapathi*, bread, *samosa*, *upma*, etc. Particularly in both states particularly in tribal areas, raw material availability is high. Thus pickles making units can be promoted in tribal areas (Sekar and Muniyappa, 2007). Fully matured fresh vegetables, fruits, are washed and cut into required sizes and add salt, mirchi, oil and other ingredients in required quantity. The preparation of all pickles is similar and very popular mango pickle in AP is depicted in Fig. 2. The freshly prepared pickles are to be cured for a week and packed in different sizes with labeling and dispatched for market in commercial preparations. The same process also for non-veg pickles. The durability of the non-veg pickles is very short. The addition of salt to the pickles restricts gram negative bacteria and enhance the growth of lactic

acid bacteria. In all types of pickles the dominant organisms are *Leuconostoc mesenteroids*, *L.pallax* and *Lactobacillus plantarum* including these *Staphylococcus aureus*, *Saccharomyces cerevisiae* and *A. niger* also present when pickle spoiled.

INDIGENOUS FERMENTED BEVERAGES

Toddy and palm wine are alcoholic beverages that are made by fermenting the sugary sap from various palm plants. Virtually any sugary plant sap can be processed into an alcoholic beverage – it just needs the correct yeasts, temperature and processing conditions (Joshi, 2016). Throughout the world, alcoholic drinks are made from the juices of locally grown plants including coconut palm, oil palm, wild date palm, nipa palm, raphia palm, Caryota palm and kithul palm.

Palm Wine

Palm wine is the fermented sap of certain varieties of palm trees including raphia palm (*Raphia hookeri* or *R. vinifera*) and the Caryota palm (*Jeeluga*). It is collected by tapping the top of the trunk. There are many variations of the same product and no individual method or recipe. Palm wine is particularly common South India (Shamala and Sreekantiah, 1988). The sap use to collect from a growing palm. It is collected by tapping the palm. This involves making a small incision in the bark of the palm, about 15 cm from the top of the trunk. A clean gourd is tied around the tree to collect the sap, which runs into it. The sap is collected each day and should be consumed within 5-12 hours of collection. Fresh palm juice is a sweet, clear, colourless juice containing 10-12 percent sugar. The sap is not heated and the wine is an excellent substrate for microbial growth. It is therefore essential that proper hygienic collection procedures are followed to prevent contaminating bacteria from competing with the yeast and producing acid instead of alcohol (Fig. 3). Fermentation starts soon after the sap is collected and within an hour or two becomes reasonably high in alcohol (up to 4%). If allowed to continue to ferment for more than a day, it starts turning into vinegar. The quality of the final wine is

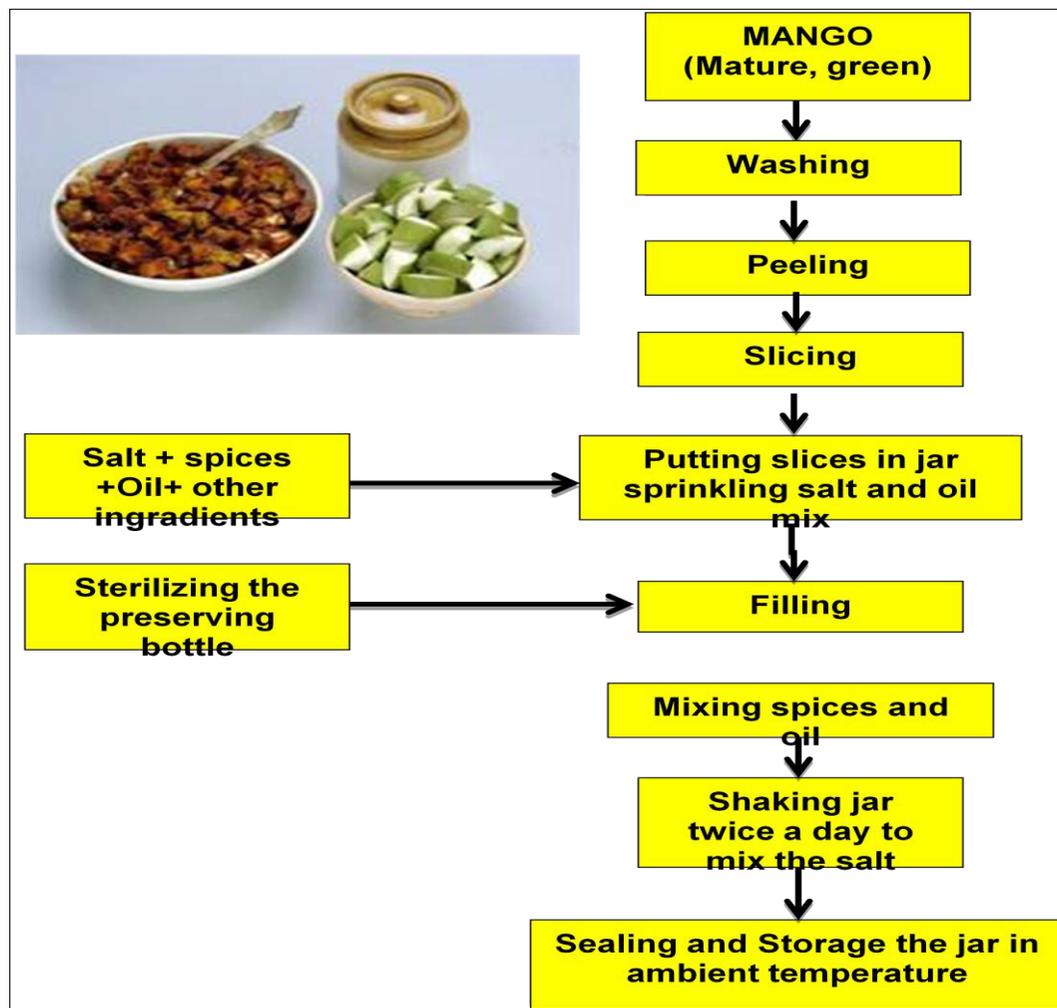


Fig. 2: Flow chart of mango pickle preparation

determined by the conditions used for the collection of the sap. Often the collecting gourd is not washed between collections and residual yeasts in the gourd quickly begin the fermentation. This is beneficial as it prevents the growth of bacteria which can spoil the sap (Grimwood and Ashman, 1975). Packaging is usually only required to keep the product clean and to transport it for its relatively short shelf life. Clean glass or plastic bottles should be used. The product should be kept in a cool place away from direct sunlight.

Toddy

Toddy is an alcoholic drink made by the fermentation

of the flower sap from a coconut palm (*Cocus neusifera*). Fresh coconut sap contained 12-15% of sucrose (by weight) and trace amount of reducing sugar including glucose, fructose, maltose and raffinose. The sap contains approximately 0.23% protein, 0.02% fat. Half of the total sugars are fermented during first 24 hours and ethanol content of the fermented palm sap reaches maximum of 5.0 – 5.28% (v/v) after 48 h (Sekar and Mariappan 2005 and 2007). After fermentation it is white and sweet with a characteristic flavour and contains between 4 and 6% alcohol. There are two main types of *kallu* in Andhra Pradesh, namely *Thadi kallu* (from Toddy Palmyra trees) and *Eetha kallu* (from silver date palms). *Eetha Kallu* is very sweet and less

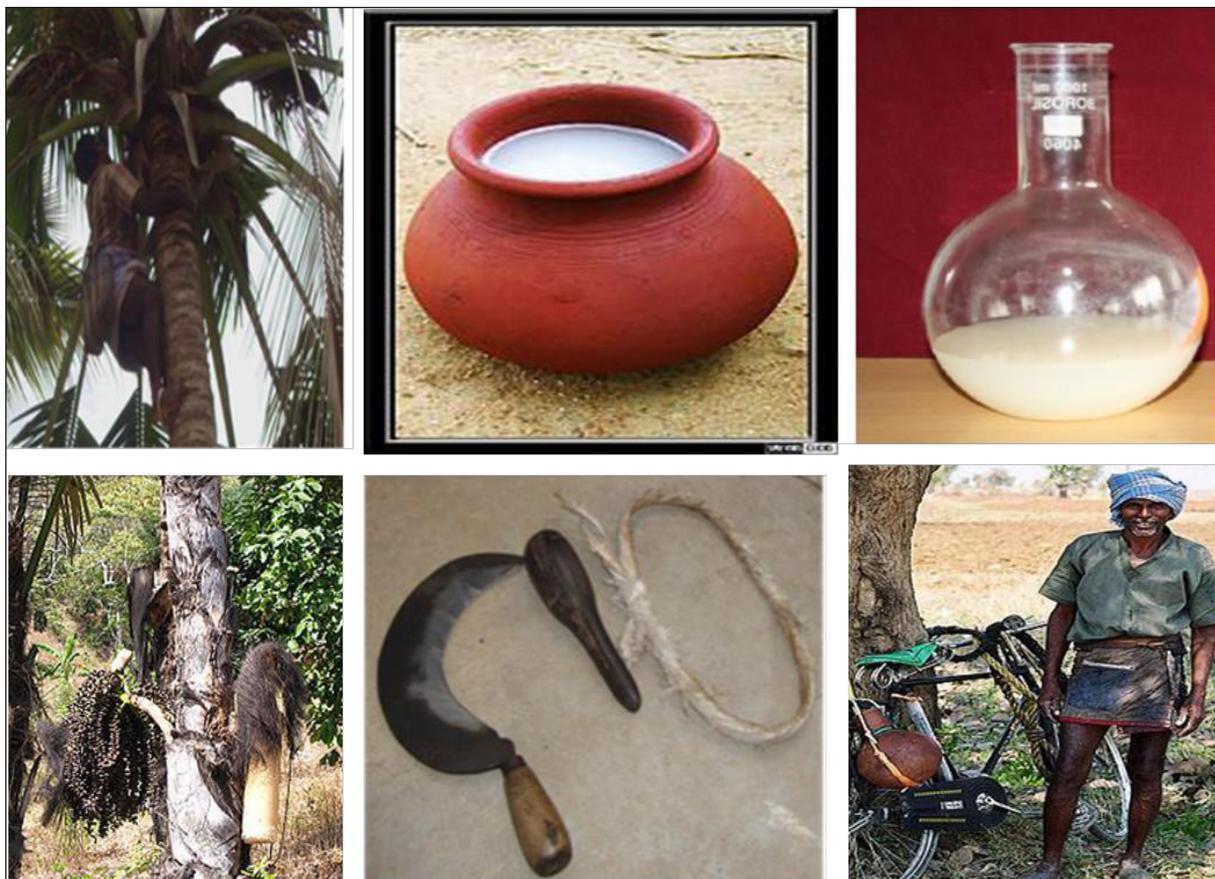


Fig. 3: Palm /Toddy wine collection and Toddy collector in Andhra Pradesh

(From left to right 1. Coconut tree, 2. Toddy wine in earthen pot, 3. palm wine collected in glass beaker, 4. Palm tree, 5. Instruments used to collect palm/toddy wine and 6. Toddy collector)

Source: Half yearly report on standardization of selected ethnic fermented foods and beverages by rationalization of indigenous knowledge C30031.

intoxicating, whereas *Thati Kallu* is stronger (sweet in the morning, becoming sour to bitter-sour in the evening) and is highly intoxicating. A small amount of toddy from the previous day's fermentation should be left in the pot to start the fermentation (Fig. 3). A natural fermentation takes place due to yeasts that are present in the sap and those that are added from a previous batch of toddy. The sugar in the sap is partly fermented to alcohol, which helps to preserve the product. It requires refrigeration if it needs to be stored for more than 24 hours. The collecting pots should not be washed out. That way they retain a small amount of starter inoculum for future fermentations. However, it is important to

ensure that they are kept clean and do not become contaminated by other bacteria. The fermentation vessels should be kept clean and the product must be hygienically handled (Law *et al.* 2011). Shamala and Sreekantiah (1988) reported that the fermentation produces mainly ethanol, acetic acid and lactic acid. pH of the sap rapidly dropped from around 7.2 to 5.5 due to formation of acetic acid and ethanol content drastically increased to 5% (v/v) within 8 hours. Palm wine contains 5% (v/v) ethanol, lactic and acetic acids 1-1.5%. Palm wine was found rich in mineral as it contains 0.019 – 0.028% (w/v) of vitamin B-12 and 0.008% of ascorbic acid (Van Pee and Swings, 1971; Steinkraus, 1994).

The palm sap fermentation involved alcoholic–lactic–acetic acid fermentation, by the presence of mainly yeasts and lactic acid bacteria. Aidoo *et al.* (2006) concluded that *Saccharomyces* spp. present in the natural fermented palm sap and are important for the formation of characteristic aroma of the palm wine. *S. cerevisiae* and *S. pombe* have been reported to be the dominant yeast species (Odunfa and Oyewole, 1998). Other yeast species such as other *Candida* spp and *Pichia* spp. are also present (Atacador-Ramos, 1996). Lactic acid bacteria and other bacteria such as *Lactobacillus plantarum*, *L. mesenteroides*, *Acetobacter* spp. and *Zymomonas mobilis* are also present. The microorganisms are reported to originate from the palm tree, the gourd used for sap collection and fermentation, or the tapping equipment. Study done by Atputharajah *et al.* (1986) reported the presence of seventeen (17) species of yeasts and seven (7) genera of bacteria in the natural fermented coconut palm sap. Yeast species found include the *Candida paropsilosis*, *C. tropicalis*, *C. valida*, *K. javanica*, *Pichia etchellsii*, *P. farinose*, *P. guilliermondi*, *P. membranaeficiens*, *P. ohmeri*, *Rhodotorula glutinis*, *Saccharomyces chevalieri*, *S. ludwigii*, *S. bailii*, *Schizosaccharomyces pombe*, *Sporobolomyces salmonicolor* and *Torulopsis* spp. *Bacillus* is the predominant bacteria genus while others included *Enterobacter*, *Leuconostoc*, *Micrococcus* and *Lactobacillus*.

Sara

Sara is a distilled liquor and very popular alcohol beverage/drink in villages of Andhra Pradesh which also called *Naatusarai* (country *Sara*). It is used to prepare in festive seasons like *Sankranthi*, *Ugadi* and *Vijayadasimi*. It contains high alcohol concentration around 20-25% (v/v). Rice flour, black jiggery and bark of white acacia tree are used in the preparation of *Sara*. It is prepared by anaerobic fermentation with in porous earthen pots that kept in deep soil for 10-15 days. After the fermentation it is distilled using pot distillation method. In some varieties different fruits/ and nuts banana, orange, guava, mango also used to get best quality *Sara*. But after the fermentation the *Sara* prepared with the addition of fruits and nuts

is filtered through sieves and resulting filtrate is consumed directly.

CONCLUSION

Fermented foods is important to human's diet and possess a natural and healthy image. Traditional fermented foods of Andhra Pradesh (AP) are prepared at the house hold level and only few are commercialized. There are very few reports on traditional fermented foods of Andhra Pradesh. Most of the countries have been well investigated and documented their traditional fermented foods and beverages. In India and in Andhra Pradesh, most of the traditional fermented foods and beverages are yet to be investigated. Only a few common fermented foods such as *idli*, *dosa*, *dahi* have been studied so far. Isolation, purification and identification of dominant microorganisms involved in traditional fermented foods and beverages are important aspects of such studies. Identification of predominant microorganisms through phenotypic and genotypic molecular methods such as 16S rRNA sequences, FISH, metagenomics tools with the aid of computer informatics, chemotaxonomic tools such as cell wall studies, cellular fatty acids and isoprenoid, quinones are helpful, when the conventional methods of identification is not possible. Due to the presence of various ethnic groups in India we have a diversified food habits. There is a need to study the microbial diversity associated in fermented foods may contribute a significant gene pool, which must not be lost in this generation. This is right time to commercialize our popular and acceptable traditional fermented foods, some of which may present unknown potent microorganisms which could be of scientific interest or may have potential industrial application.

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