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ORIGINAL ARTICLE

Selection of starter cultures for *idli* batter fermentation and their effect on quality of *idlis*

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Abstract *Idli* batter samples were prepared using lactic starter cultures like *Pediococcus pentosaceus* (Pp), *Enterococcus faecium* MTCC 5153 (Ef), *Ent. faecium* (IB2 Ef-IB2), individually, along with the yeast culture, *Candida versatilis* (Cv). *Idli* batter prepared using Ef and Ef-IB2 cultures gave better results, when evaluated for the rise in batter volume (80 ml), level of CO_2 production (23.8%), titratable acidity 2.4–3.5% (lactic acid) and pH 4.3–4.4. Storage stability of batter made with selected starter cultures was determined by analyzing the *idlis* prepared using the batter stored for 1 and 5 days for texture, nutrient composition and sensory quality. Slight variations in the results were seen among the *idlis* of different combination of cultures, whereas these results are better than that of the *idlis* made using naturally fermented *idli* batter. Sensory profile of *idlis* prepared using starter cultures had a higher score (3.9–4.4) compared to the control (3.6) for overall acceptability.

Keywords *Idli* · Microbial profile · Nutrition · Starter culture · Batter · Fermentation · Storage stability · Texture

Introduction

Production of fermented foods is one of the oldest food processing technologies known to man. The diversity of the population of India has given rise to a large number of traditional fermented foods which have been extensively reviewed (Soni and Sandhu 1990; Achaya 1994). Cereals and legume based foods are a major source of economical dietary energy and nutrients, worldwide. The use of desirable microorganisms, particularly those of lactic acid bacteria (LAB), yeasts and fungi have been well documented (Steinkraus 1995). *Idli* is a white, fermented acid (leavened), soft, spongy textured product and steamed cake of rice (*Oryza sativa*) and dehulled black gram dhal (*Phaseolus mungo*). *Idli* fermentation has been the subject of many research investigations and reviews, covering aspects such as methods of preparation, microbiology and nutritive value (Desikachar et al. 1960; Mukherjee et al. 1965; Steinkraus et al. 1967; Ramakrishnan 1979; Venkatasubbaiah et al. 1984; Thyagaraja et al. 1992; Agrawal et al. 2000; Rati et al. 2003, 2006; Kanchana et al. 2008; Riat and Sadana 2009). Two significant changes occurring in *idli* fermentation are leavening and acidification of the batter (Jama and Varadaraj 1999).

A starter culture can be defined as a microbial preparation of a large number of cells of at least one microorganism to be added to a raw material to ferment food by accelerating and steering the fermentation process (Leroy and De Vuyst 2004). They cause rapid acidification of the raw material through the production of organic acids, mainly lactic acid. Also, their production of acetic acid, ethanol, aroma compounds, bacteriocins, exopolysaccharides and several enzymes is of importance. In this way they enhance shelf life and microbial safety, improve texture, and contribute to the pleasant sensory profile of the end product (Leroy and De Vuyst 2004). The bacteria identified as a part of the microflora for *idli* batter fermentation included *Leuconostoc mesenteroides, Lactobacillus delbrueckii, Lb. fermentum, Lb. lactis, Lb. brevis, Streptococcus faecalis* and *Pediococus cerivisiae*, which are essential for leavening of batter and for acid production in *idli* and

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yeasts such as *Geotrichum candidum, Torulopsis holmii, T. candida, Trichosporon pullulans, Candida fragilola, C. kefyr, C. tropicalis, Hansenula anomala* and *Rhodotorula graminis*, which are responsible for pH reduction and may increase the thiamine and riboflavin content (Mukherjee et al. 1965; Reddy et al. 1981; Venkatasubbaiah et al. 1984; Charan and Kadam 1989; Soni and Sandhu 1990, Thyagaraja et al. 1992; Purushothaman et al. 1993; Steinkraus 1995; Agrawal et al. 2000). In order to reduce the fermentation time of *idli* batter and to increase the shelf life of fermented batter, an improved process for the preparation of shelf-stable *idli* batter was made available (Varadaraj et al. 1999). Detailed texture profile analysis of *idli* made from parboiled rice and decorticated black gram was reported (Balasubramanian and Viswanathan 2007). The purpose and scope of the present study was to develop a suitable combination of starter cultures for *idli* batter fermentation and to evaluate the quality of batter and *idli*s for nutritional, textural and sensory quality.

Materials and methods

Media For cultivation and maintenance of LAB, *Lactobacillus* deMan- Rogosa- Sharpe agar (MRS agar) and for yeasts Sabouraud dextrose (SD) agar (Hi-Media Laboratories Pvt Ltd, Mumbai, India) were used. The lactic cultures were incubated at 37°C for 16 h for the cells to reach late exponential phase in static condition and the yeast culture was grown at 30°C for 48 h.

Preparation of idli batter: Idli batter was prepared from the mixture of milled rice (*Oryza sativa*) and dehulled black gram (*Phaseolus mungo*) dhal in 4:1 ratio. The ingredients (rice and dhal) were processed using good manufacturing process (Agrawal et al. 2000). Soaking was done in potable water for 6–8 h. These ingredients were ground to a fine paste under hygienic conditions (Varadaraj et al. 1999) and pH of the fresh *idli* batter was checked. Four different starter cultures were used to prepare different *idli* batter samples using the following combinations: i) *Pedicoccus pentosaceus+Candida versatilis*, ii) *Enterococcus faecium* MTCC 5153+*Candida versatilis* and iii) *Enterococcus faecium* IB2+*Candida versatilis*. These combinations of starter cultures were added to the *idli* batter sample at 1% inoculum 0.5% LAB and 0.5% yeast. *Idli* batter prepared using the traditional method (without steaming the ingredients and without boiling the water used for soaking and grinding and without any added culture natural fermentation) was used as control. For the analysis of texture, nutrient composition and sensory profile of *idli* samples, the batter samples were prepared individually using 3 different combinations of cultures and naturally fermented batter

Table 1 Effect of starter culture in increasing the batter volume, titratable acidity and pH during *idli* batter fermentation

Storage period days	Combination of starter cultures											
	PP+Cv			Ef-IB2+Cv			Ef+Cv			NF		
	RBV	TA	pH	RBV	TA	pH	RBV	TA	pH	RBV	TA	pH
0	100	ND	6.73	100	ND	6.73	100	ND	6.73	100	ND	6.73
1	105 ± 2.30^{a}	0.7 ± 0.11^{a}	4.7 ± 0.22^{a}	115 ± 2.12^{b}	0.9 ± 0.11^{a}	4.8 ± 0.121^{a}	115 ± 1.81^{b}	1.2 ± 0.11^{a}	4.7 ± 0.12^{a}	30 ± 3.53^{c}	1.0 ± 0.11^{a}	4.8 ± 0.25^{a}
2	105 ± 3.11^{a}	1.7 ± 0.10^{b}	4.6 ± 0.31^{a}	135 ± 3.21^{b}	1.4 ± 0.10^{b}	4.7 ± 0.22^{a}	135 ± 4.12^{b}	1.7 ± 0.13^{a}	4.7 ± 0.15^{a}	140 ± 3.12^{c}	1.6 ± 0.15^{b}	4.7 ± 0.13^{a}
3	105 ± 4.80^{a}	2.1 ± 0.21^{c}	4.6 ± 0.35^{a}	155 ± 3.51^{d}	2.0 ± 0.21^{c}	4.6 ± 0.11^{a}	155 ± 5.51^{c}	2.3 ± 0.25^{a}	4.5 ± 0.21^{a}	140 ± 2.51^{b}	2.2 ± 0.21^{c}	4.6 ± 0.34^{a}
4	105 ± 3.72^{a}	2.7 ± 0.12^{d}	4.6 ± 0.21^{a}	180 ± 4.01^{c}	2.7 ± 0.32^{e}	4.5 ± 0.31^{a}	180 ± 6.11^{c}	2.9 ± 0.33^{a}	4.4 ± 0.31^{a}	140 ± 3.22^{b}	2.9 ± 0.12^{d}	4.5 ± 0.22^{a}
5	105 ± 2.52^{a}	$3.3\pm.0.21^{e}$	4.4 ± 0.41^{a}	180 ± 3.81^{c}	2.6 ± 0.11^{d}	4.4 ± 0.22^{a}	180 ± 5.85^{c}	3.6 ± 0.11^{a}	4.3 ± 0.21^{a}	140 ± 2.81^{b}	3.5 ± 0.21^{e}	4.5 ± 0.11^{a}

PP Pediococcus pentosaceus; *Ef Enterococcus faecium* MTCC 5153; *Ef-IB2 Ent. faecium* IB_2; *Cv Candida versatilis*; *NF* Natural fermentation; *RBV* Rise in batter volume; *TA* Titratable acidity (% lactic acid); *ND* Not determined

Mean scores, in a row within the treatment, without common superscripts are significantly different ($p<0.05$) ($n=3$)

Table 2 Rate of carbon dioxide production by different starter cultures during *idli* batter fermentation

Fermentation period, days	Amount of CO_2 produced (%)/Combinations of starter culture			
	Pp+Cv	Ef-IB2+Cv	Ef+Cv	NF
PET laminated LDPE				
1	14.6±1.55^{b}	15.3±1.42^{b}	16.2±1.51^{b}	12.0±1.43^{a}
2	16.2±1.62^{b}	16.2±1.36^{b}	17.3±1.44^{b}	12.0±1.51^{a}
3	17.1±1.51^{a}	17.7±1.44^{a}	18.7±1.52^{a}	21.3±1.44^{b}
4	19.3±1.63^{a}	19.9±1.52^{a}	20.2±1.54^{a}	21.3±1.63^{a}
5	20.3±1.58^{a}	22.2±1.45^{b}	23.8±1.62^{b}	23.0±1.52^{b}
Aluminum foil laminated LDPE				
1	16.4±1.15^{a}	21.6±1.19^{b}	21.9±1.22^{b}	23.0±1.41^{b}
2	22.7±1.26^{a}	26.4±1.22^{b}	26.9±1.41^{b}	27.3±1.33^{b}
3	25.3±1.28^{a}	30.0±1.42^{b}	29.0±1.53^{b}	35.0±1.41^{c}
4	27.8±1.58^{a}	30.9±1.31^{b}	31.1±1.51^{b}	41.4±1.46^{c}
5	29.3±1.42^{a}	30.2±1.26^{a}	32.2±1.4^{3b}	45.6±2.17^{c}
HDPE plastic ware with air tight lid				
1	12.2±1.12^{b}	9.3±1.02^{a}	9.6±1.11^{a}	12.3±1.12^{b}
2	13.7±1.02^{b}	11.7±1.21^{a}	12.2±1.12^{a}	13.9±1.21^{b}
3	15.9±1.22^{b}	13.9±1.11^{a}	15.8±1.13^{b}	15.2±1.46^{b}
4	16.3±1.12^{ab}	15.4±1.14^{b}	17.3±1.23^{b}	16.8±1.55^{ab}
5	17.0±1.31^{a}	17.2±1.12^{a}	20.8±1.45^{b}	17.9±1.41^{a}

PP Pediococcus pentosaceus; *Ef Enterocuccus faecium* MTCC 5153; *Ef-IB2 Ent. faecium* IB_2; *Cv Candida versatilis; NF* Natural fermentation

Mean scores, in a row within the treatment, without common superscripts are significantly different ($p<0.05$) ($n=3$)

were packed in polyethylene terephthalate—low density polyethylene (PET-LDPE) laminated pouches and stored at 30°C.

Analysis of *idli* batter

Rise in batter volume The *idli* batter prepared using 3 different culture combinations and the batter without any added culture was poured into 500 ml measuring cylinders, individually, up to 100 ml mark, covered with aluminum foil and were kept at 30°C for 24 h and observed for rise in batter volume. The rise in CO_2 production can be correlated with the increase in batter volume. The four *idli* batter samples were freshly prepared and packed in following three different packaging materials, PET-LDPE laminated pouches, air tight high density polyethylene (HDPE) tins and aluminum foil laminated LDPE pouches. The amount of CO_2 produced was analyzed and compared.

The pH of the *idli* batter samples was checked individually using a microprocessor based digital pH meter (Henna Instruments, Singapore). The CO_2 produced during fermentation of *idli* batter packed in 3 types of packing material, as indicated above, was analyzed using PBI Dansen analyzer. The microbial load of the batter stored at 30 and 10°C was checked for 0–7 days. The batter samples were serially diluted with 0.8% saline individually and appropriate dilutions were pour plated individually using MRS agar (for lactics) and spread plated on SD agar (for yeasts) plates. The plates were incubated at 37°C for 24–48 h. The colonies were counted using colony counter. The microbial load was estimated until the product became deteriorated with visual observation of yeast and molds growth.

Table 3 Textural quality shear force, (Newton) of *idlis* prepared using different starter cultures

Fermentation period, days	Combination of starter cultures			
	PP+Cv	Ef- IB2+Cv	Ef+Cv	NF
1	6.4±1.14^{aS}	5.3±0.91^{a}	5.7±0.55^{a}	9.5±1.15^{b}
5	8.5±1.25^{b}	9.0±1.14^{b}	8.2±0.92^{b}	ND

PP Pediococcus pentosaceus; *Ef Enterocuccus faecium* MTCC 5153; *Ef-IB2 Ent. faecium* IB_2; *Cv Candida versatilis; NF* Natural fermentation; *ND* Not determined

Mean scores, in a column within the treatment, without common superscripts are significantly different ($p<0.05$) ($n=3$)

Evaluation of idlis prepared using selected starter culture The *idlis* made from batter samples prepared using selected combinations of starter cultures and stored for 1 and 5 days were evaluated for textural, sensory and nutritional parameters. The hardness of *idlis* was tested using Instron texture analyzer (Lloyds Instron texturomenter LRSK, UK) through shear force measurement. The shear force values in Newton (N) recorded under the operating conditions of 100 kg load with 100 mm/min plunger speed and shear plunger. The sensory evaluation of *idlis* prepared by the selected combinations of starter cultures was carried out organoleptically. The *idlis* were evaluated by 50 untrained judges in respect of colour, flavour, appearance, taste and overall acceptability, using 5-point Hedonic scale rating (Watts et al. 1989). The mean of the scores is reported. For estimation of moisture content method described by (Bemal et al. 2004) was used. *Idlis* (10 g) prepared using different batter were dried to a constant weight in a hot air oven at 100°C and the moisture content was estimated. To determine the ash content (Bemal et al. 2004), 5 g of batter samples were placed in pre-dried crucibles, individually and kept in a muffle furnace at 550°C until they appeared clean and white. Thiamine content was estimated after extracting it from the batter in acidic condition. It was oxidized to thiachrome by alkaline potassium ferricyanide and the intense blue colour fluorescence exhibited by thiochrome was measured fluorometrically as described by (Bemal et al. 2004). The carbohydrate content was determined by the calorimetric method as described by (Ranganna 1977). The energy or calorific value of *idlis* was determined by oxidizing a known weight of *idlis* in Bomb calorimeter (Rajdhani, CD-RSB5, Jaipur, India) and the heat produced was measured and expressed in terms of kcal. Nitrogen content was measured using microKjeldahl method (Bemal et al. 2004). Fat soluble material of *idlis* was extracted with ether bp 40°C from an oven dried sample using Soxhlet extraction method (Bemal et al. 2004). The iron content of *idlis* was determined by converting the iron to ferric form using oxidizing agent (hydrogen peroxide) and treated with potassium thiocyanate to form the red ferric thiocyanate, which was measured colorimetrically at 480 nm using a spectrophotometer (Elico, Scanning mini spec, Hyderabad, India).

Statistical analysis The data in triplicate was subjected to statistical analysis by Duncan's multiple range test (Duncan 1955).

Results and discussion

Both the *Enterococcus* cultures used in this study produced anti-listerial bacteriocin (Sangeetha et al. 2007). The pH of the samples ranged between 4.5 and 4.3 (Table 1). The combination of Ef and yeast showed high acidity compared to other combinations of starter cultures. Titratable acidity of the samples differed from 3.5 to 2.3%. At the end of fifth day, the combination of starter cultures namely, Ef and yeast and also Ef-IB2 and yeast gave better rise in volume up to 80% than the other combinations, suggesting that it was producing acid (due to lactics) and gas production (mainly by yeast) and with a titratable acidity of 2.3%.

Quantitative analysis of CO_2 production Rate of CO_2 production was higher in samples packed with aluminum foil-LDPE laminate pouches compared to other two packing materials (Table 2). It might be due to the non-permeability of aluminium foil to gas. The highest amount of CO_2 production in natural fermentation was 45.6% in aluminum foil-LDPE laminate pouches. Among all the three combinations of the cultures used, the combination of

Table 4 Nutrients in *idlis* prepared using different starter cultures

Parameter	Day 1			Day 5			
	PP+Cv	Ef-IB2+Cv	EF+Cv	NF	PP+Cv	Ef-IB2+Cv	Ef+Cv
Moisture g (%)	51.9±1.41[a]	50.9±2.82[a]	50.2±2.62[a]	50.5±1.12	50.2±3.12[a]	48.0±2.82[a]	49.0±3.62[a]
Energy kcal)	42.8±2.52[b]	43.4±2.76[b]	43.1±3.24[b]	43.2±1.04	37.2±2.44[a]	37.7±1.94[a]	38.1±3.14[a]
Carbohydrate g (%)	8.1±1.14[a]	7.7±1.42[a]	7.9±0.82[a]	8.2±0.92	7.4±0.92[a]	6.3±0.82[a]	6.7±1.52[a]
Protein g (%)	3.3±0.65[a]	3.2±0.64[a]	3.2±0.14[a]	3.3±0.22	3.0±0.42[a]	2.9±0.32[a]	3.0±1.34[a]
Fat g (%)	0.2±0.11[a]	0.1±0.12[a]	0.1±0.16[a]	0.1±0.11	0.1±0.22[a]	0.1±0.14[a]	0.1±1.46[a]
Iron mg	1.9±0.11[b]	2.8±1.21[b]	2.8±0.12[b]	3.8±0.32	ND	0.9±0.16[a]	0.9±0.11[a]
Ash g (%)	36.7±2.24[a]	37.8±2.33[a]	38.3±2.12[a]	38.2±2.82[a]	35.4±2.12[a]	36.4±2.52[a]	37.4±2.48[a]

PP Pediococcus pentosaceus; *Ef Enterocuccus faecium* MTCC 5153; *Ef-IB2 Ent. faecium* IB_2; *Cv Candida versatilis; NF* Natural fermentation; *ND* Not detected

Mean scores, in a row within the treatment, without common superscripts are significantly different ($p<0.05$) ($n=3$)

Ef and yeast resulted in higher CO_2 production in all types of packing materials and the maximum of 32.2% was observed in pouches prepared with aluminum foil-LDPE laminate. The combination of starter cultures of Ef-IB2+Cv and Ef+Cv produced high rate of CO_2 due to the metabolic activity of yeast and its compatibility with added lactic culture. The rate of CO_2 production due to microbial fermentation can directly be correlated to the rise in batter volume. This is due to of a large number of yeasts present in the batter.

Texture analysis The hardness of *idlis* increased with longer storage period and it was high on 5 day old *idli* batter when compared to 1 day old *idli* batter (Table 3). The *idlis* prepared using naturally fermented batter required greater force to break. Hence, the *idlis* prepared from Ef-IB2 and yeast and Ef and yeast combinations were more soft compared to *idlis* prepared from the combination of Pp+yeast culture. The hardness of *idlis* increased due to the increase in acidity.

Nutrient analysis of idlis The observations of the first and the fifth day samples showed variations in the nutrient content (Table 4). The nutrient contents were higher in first day sample compared to fifth day sample. In the first day sample, Pp+Cv combination gave better result for protein and fat and the carbohydrate content was higher in Ef-IB2+Cv. The natural fermented *idlis* had high contents of carbohydrate, protein and iron. In the 5th day sample, the higher carbohydrate content in *idlis* prepared using Pp+Cv, higher fat content in Ef-IB2+Cv and higher energy in the *idlis* prepared using EF+Cv combination were noticed. The thiamine was not detected in *idli* of any combination of cultures. It may be due to the polished rice used for the batter preparation. From the results, much difference was not seen among the *idlis* prepared with these combinations of cultures and the *idlis* prepared using the batter fermented naturally. Formation of acids can both increase the levels of bioactive compounds such as total amount of phenolic compounds or decrease the levels of some other compounds, such as thiamine, ferulic acid, dehydrodimers, tocopherols and tocotrienols (Boskov-Hansen et al. 2002; Liukkonen et al. 2003).

Microbial profile Increase in viable count was observed till day 4 and day 6 in the samples maintained at 30 and at 10°C conditions, respectively (Table 5). After that, the samples kept at 30°C were spoiled, whereas, in the samples stored at 10°C, the decrease in the viable count was observed in all the combination of starter cultures. In day 1 samples, the microbial load indicated high yeast count which related to higher CO_2 production and less lactic count, giving soft texture to *idlis*. In day 5 sample, low yeast count

Table 5 Microbial profile of *idli* batter at different storage temperatures

Storage Period, days	Microbial count (Log10 cfu/g)											
	PP+Cv				Ef-IB2+Cv				Ef+Cv			
	10°C		30°C		10°C		30°C		10°C		30°C	
	Lactics	Yeasts	Lactics	Yeasts	Lactics	Yeasts	Lactics	Yeasts	Lactics	Yeasts	Lactics	Yeasts
0	–	–	7.3[a]	7.3[a]	–	–	7.1[a]	7.3[a]	–	–	7.1[a]	7.4[a]
1	8.6±1.12[a]	8.7±1.22[a]	9.2±1.42[b]	9.25±1.42[b]	8.6±1.22[a]	8.7±1.22[a]	9.1±1.32[b]	9.2±1.22[b]	8.3±0.94[a]	8.6±0.62[a]	9.1±0.12[b]	9.4±1.34[b]
2	8.7±0.94[a]	8.8±1.32[a]	9.3±1.52[b]	9.29±1.22[b]	8.8±1.12[a]	8.8±1.02[a]	9.3±0.84[b]	9.3±1.14[b]	8.6±0.88[a]	8.8±0.52[a]	9.4±1.52[b]	9.4±1.22[b]
3	8.8±0.82[a]	9.0±1.54[a]	9.5±1.42[b]	9.4±1.32[b]	9.0±1.44[a]	9.1±1.14[a]	9.5±0.92[b]	9.5±1.23[b]	8.6±0.62[a]	8.9±0.92[a]	9.6±1.34[b]	9.5±1.54[b]
4	ND	ND	10.1±1.64[c]	10.01±1.44[c]	ND	ND	10.1±1.24[c]	10.1±1.6[c]	ND	ND	9.9±1.66[b]	10.0±1.78[b]
5	ND	ND	9.2±1.02[b]	9.0±1.12[b]	ND	ND	9.2±1.16[b]	9.1±1.14[b]	ND	ND	9.3±1.02[b]	8.8±1.12[b]
6	9.1±1.22[a]	9.1±1.42[a]	ND	ND	9.0±1.22[a]	9.1±1.12[a]	ND	ND	9.0±1.02[a]	9.0±1.02[a]	ND	ND
7	8.9±1.11[a]	9.0±1.12[a]	ND	ND	9.0±1.32[a]	9.1±1.02[a]	ND	ND	8.9±0.92[a]	9.0±0.64[a]	ND	ND

PP Pediococcus pentosaceus; *Ef Enterocuccus faecium* MTCC 5153; *Ef-IB2 Ent. faecium* IB_2; *Cv Candida versatilis; NF* Natural fermentation; *ND* Not Determined; Results are average of 3 independent experiments done in duplicate with standard deviation

Mean scores, in a row within the treatment, without a common letters are significantly different ($p<0.05$) by DMRT

Table 6 Sensory scores of fresh *idlis* prepared using selected combinations of starter cultures

Parameter	PP+Cv		Ef-IB2+Cv		Ef+Cv		NF	
	1[e]	5	1	5	1	5	1	5
Appearance	3.7±0.12[a]	3.5±0.12[a]	3.7±0.22[a]	3.1±0.22[a]	3.1±0.14[a]	3.2±0.12[a]	3.5±0.12[a]	ND
Colour	3.5±0.14[a]	2.8±0.22[a]	4.0±0.42[b]	2.6±0.14[a]	3.7±0.44[a]	2.5±0.12[a]	3.6±0.22[a]	ND
Flavour	4.5±0.32[c]	3.0±0.14[b]	4.4±0.44[c]	2.8±0.32[a]	4.1±0.56[b]	2.8±0.34[a]	3.8±0.26[a]	ND
Taste	4.3±0.26[a]	2.3±0.22[a]	4.0±0.36[a]	2.2±0.22[a]	4.2±0.44[a]	2.4±0.26[a]	3.9±0.24[a]	ND
Overall acceptability	3.9±0.32[b]	2.3±0.24[a]	4.4±0.32[d]	2.3±0.12[a]	4.2±0.58[c]	2.4±0.22[b]	3.6±0.22[a]	ND

PP Pediococcus pentosaceus; *Ef Enterocuccus faecium* MTCC 5153; *Ef-IB2 Ent. faecium* IB_2; *Cv Candida versatilis; NF* Natural fermentation; [e] Storage period of batter in days at 30°C. *ND* Not done

Mean scores, in a row within the treatment, without common superscripts are significantly different ($p<0.05$) ($n=50$ panelists)

was observed compared to lactic count, produced high acidity and gave hardness to the final product. This confirms the necessity of cold storage to extend the shelf life of batter beyond 1 day. Decrease in viable count beyond 4 days of storage might be due to increased acidic conditions due to the fermentation of ingredients by the lactic cultures.

Sensory profile The results of Table 6 indicate that the overall acceptability decreased with increase in storage period of *idli* batter. In the first day, the Pp+Cv combination of *idli* had high score for appearance, flavour and taste. However, the overall acceptability and the colour scores were good for Ef-IB2+Cv combination. On the fifth day, the appearance, colour and flavour scores were good for Pp+Cv. However, overall acceptability was good for *idlis* prepared by using Ef+Cv cultures. Thus the *idlis* made from Ef+Cv combination showed better results compared to *idlis* prepared using the combination of Ef-IB2+Cv after 5 days storage.

Conclusion

The effect of 2 different strains *Enterococcus faecalis*, *Pediococcus pentosaceus* and the yeast *Candida versatilis* on the quality of *idli* batter fermentation and sensory quality of the *idlis* was studied. Slight variation in the results of the physic-chemical parameters like rise in batter volume, pH and acidity were seen in batter fermented by different combination of cultures. However, these results are higher than that of the *idlis* made using naturally fermented *idli* batter. Aluminum foil laminated LDPE pouches were found to be better in extending the keeping quality of the batter. Sensory profile of the *idlis* prepared using starter cultures *Ent. faecium* IB2 and *Candida versatilis* had a higher score (4.4), when compared to the control (3.6) for overall acceptability. This clearly indicates the importance of use of starter cultures in the preparation of fermented foods than the natural fermentation. Thus use of this culture can help to extend the keeping quality of the batter.

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