



Evaluation of little millet *Paddu* for physico-chemical nutritional, microbiological and sensory attributes

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ABSTRACT

The present study was undertaken to evaluate little millet *paddu* for physico-chemical, nutritional, microbiological and sensory attributes as compared to rice *paddu*. The standardized proportion of ingredients of cereal to mixture of pulse in the ratio of 6:1 (little millet 81.48, black gram dhal 13.58, bengal gram dhal 1.36, red gram dhal 1.36, fenugreek seed 0.82 and flaked rice 1.4g) and 4:1 (rice 74.58, black gram dhal 18.64, bengal gram dhal 1.86, red gram dhal 1.86, fenugreek seed 1.12 and flaked rice 1.94g) was used for little millet and rice *paddu* respectively. Processing treatments like soaking for 6 h and fermentation for 14 hr were used for preparation of *paddu*. Significant differences were observed in the increase in the volume, bulk density, specific gravity, pH and titratable acidity of little millet batter. The changes in physical characteristic of *paddu* with respect to total volume, average volume and bulk density were significant for little millet and rice *paddu*, whereas the total number, total weight of *paddu* and average weight of *paddu* did not show significant changes. Little millet *paddu* was highly nutritious than rice *paddu* and did not show significant difference in the scores of sensory attributes. Significant difference in the microbial population in fermented batter was observed between little millet and rice. *L.mesenteroides*, *Lactobacillus spp.* and yeast dominated the fermentation process among all the microorganisms. In little millet *paddu*, yeast were observed whereas in rice *paddu* bacteria were present. *E.coli* were absent in both the *paddu*.

Key words: Fermentation, Functional quality, Little millet, Microbial analysis, *Paddu*, Proximate composition.

INTRODUCTION

Paddu is a fermented breakfast food item of Southern India, commonly consumed in homes. It is a golden brown, round and soft shallow fried products of rice and mixture of pulses (Madalageri *et al.* 2011). In millet growing areas of Karnataka, traditionally *paddu* is also prepared from little millet (Shanthakumar *et al.* 2010). Little millet is a staple food for people of arid and semi arid tropical regions of Asia. In recent years this millet has been completely replaced by rice as there are no alternative value added products of millet. It is a good source of dietary protein, fibre and micronutrients however it is not considered in any appreciable amounts because of its astringent taste and presence of anti-nutrients. Fermentation is one of the traditional technologies that bring about changes in the food which improves taste, texture, nutrient content and also nutritive value and digestibility. The traditional or developed fermented foods contain high nutritive value and hence developed a diversity of flavours, aromas, and textures in food substrates (Taiwo 2009). Many of the indigenous fermented products of cereals are valued for the taste and aroma. By combining rice with pulse, the overall protein quality also improves. Recent studies on fermented *paddu* of little millet have reported that little millet *paddu* has better soft texture than rice *paddu* (Madalageri *et al.* 2011). The

optimum duration of soaking and fermentation for preparation of little millet *paddu* is 6 hr and 12-16 hr respectively (Madalageri *et al.* 2013). Little millet *paddu* can be introduced as a nutritious and profitable fermented breakfast item similar to idli in institution catering centres as consumers have highly accepted the product (Yenagi *et al.* 2013). Training efforts in marketing of little millet products to rural women entrepreneurs have made them as successful entrepreneurs (Yenagi *et al.* 2010 and Yenagi 2011). To strengthen the research area of little millet for diversified utilisation, a study was conducted to evaluate the nutritional quality and organoleptic acceptability of fermented little millet *paddu* as one of the appropriate food processing technology to stimulate agriculture production and to introduce it in catering industries.

MATERIALS AND METHODS

The little millet (*Panicum Sumatrense* L.) local cultivar (*malli savi*) was collected for the study from local farmers of Savnoor taluk, Haveri district and stored in sack bag. It was then dehusked by conventional method in emery mill. Decorticated grains were separated from the husk through winnowing. Other ingredients like rice and pulses, black gram dhal, bengal gram dhal, red gram dhal, fenugreek seeds and flaked rice were procured in bulk from the local market and stored in refrigerator at 5°C until used. Non stick

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paddu skillet was purchased from local market for preparation of *paddu*.

Method for preparation of *paddu*: The standardized proportion of ingredients of cereal to mixture of pulse in the ratio of 6:1 (little millet 81.48, black gram dhal 13.58, bengal gram dhal 1.36, red gram dhal 1.36, fenugreek seed 0.82 and flaked rice 1.4g) and 4:1 (rice 74.58, black gram dhal 18.64, bengal gram dhal 1.86, red gram dhal 1.86, fenugreek seed 1.12 and flaked rice 1.94g) was used for little millet and rice *paddu* respectively. Little millet, rice and pulse were washed twice separately and soaked in a clean beaker using distilled water for 6 h. After draining the water, grains were wet ground separately and mixed together. 150 ml of aliquot was transferred to 500 ml clean beaker and covered with aluminium foil. The batter was then allowed to ferment for 14 h in an incubator at $30 \pm 2^\circ\text{C}$. The batter was then shallow fat fried in a special non stick *paddu* skillet.

Batter properties of little millet and rice: The physical and chemical characteristics of the batter like volume, weight, bulk density, specific gravity, titratable acidity and pH were measured by standard methods before and after fermentation.

Increase in volume: A 20 ml aliquot of freshly prepared batter from different ratios of cereal and pulse was transferred to respective 50 ml measuring cylinders and covered with aluminium foil then these measuring cylinders were kept in an incubator at $30 \pm 2^\circ\text{C}$ for 12 h. And increase in the volume was noted in ml.

Net increase in volume: Net increase in volume was calculated using the following equation.

Net increase in volume = Final volume – Initial volume

Per cent increase in volume

Per cent increase in volume was calculated using following equation.

Per cent increase in volume = $\frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}}$

Weight of the batter: Weight of the batter was measured by transferring 20 ml of freshly prepared batter to previously weighed measuring cylinder. Weight of the batter before and after fermentation was noted.

Bulk density of batter and *paddu*: Bulk density of the batter was calculated using the following equation

Bulk density (g/ml) = $\frac{\text{Weight (g)}}{\text{Volume (ml)}}$

Specific gravity of batter: The specific gravity of *paddu* batter was determined by dividing the weight of glass measuring cylinder (50 ml) filled with batter to the weight of the same measuring cylinders filled with water (Kaur *et al.*, 2000).

pH: The pH of the batter was measured using the digital pH meter and the reading was directly recorded.

Titratable acidity: The acid content of the batter was measured by titrating 5 g of batter in 10 ml of distilled water against freshly prepared 0.1 N NaOH. Using the following equation, the total percent acidity was calculated.

Titrate value x normality of alkali x volume made up X milli equivalent weight of acetic acid
 $\frac{\text{Volume of sample taken x}}{\text{(weight/ volume of sample taken)}} \times 100$

Evaluation of *paddu*: Little millet and rice *paddu* were evaluated for different physical characteristic like number of *paddu*, total weight of *paddu*, total volume of *paddu*, average weight of one *paddu*, average volume of one *paddu* and bulk density of *paddu* were noted.

Total weight of *paddu*: The total weight of *paddu* was obtained by weighing all the *paddus* on digital weighing balance.

Total volume of *paddu*: The total volume of *paddu* was calculated by seed displacement method.

Sensory evaluation: Sensory evaluation was carried out using 9 point hedonic scale by 10 panel members from the department of Food Science and Nutrition, Rural Home Science College, UAS, Dharwad.

Proximate composition of *paddu*: The *paddu* was analysed for proximate composition *viz.*, moisture, ash, crude fat, crude protein, crude fibre according to the procedures of AOAC (1995) and carbohydrate was estimated by difference. Three replications were maintained in all the treatments.

Microbial analysis of batter and *paddu*

Preparation of batter and fermentation: The rice and millet batter were prepared as mentioned earlier and incubated at $30 \pm 2^\circ\text{C}$ for fermentation. At different periods, samples were used for microbiological analysis. Little millet batter and rice batter was fermented at 0, 6, 12, 18 and 24 h and used for the microbiological analysis of total bacteria, fungi, yeast, *L. mesentroides*, *Lactobacillus* sp. and *Escherichia coli*.

Microbiological analysis: The microbiological analysis of batter was carried out by following standard pour plate method. Ten ml of the batter sample was transferred to 90 ml sterilized water blank. Further dilutions were prepared by transferring one ml each in to nine ml sterilized water blanks in a series. Suitable dilutions were selected and known aliquots of one ml was transferred to sterilized Petri plates in triplicates and selective media for bacteria (Nutrient agar), fungi (Rose Bengal agar), yeast (MGYP), *Leuconostoc mesentroides* (Oenose agar), *Lactobacillus species* (Rogosa agar) and for indicator of faecal contamination *Escherichia coli* (EMBA) were poured separately and allowed for solidification. The plates were incubated at 37°C for 24-76 hrs depending on the microorganisms. The observation for colony forming units (cfu) was noted after 48 hrs for bacteria, yeast, *Lactobacillus*, *Leuconostoc mesentroides* and *E-coli*

and 46 h in case of fungi. The microbial population counts were expressed as cfu ml⁻¹ of batter.

Statistical analysis: The observations recorded for physical characteristics of batter were analysed by two way ANOVA. The data collected for organoleptic evaluation, proximate composition was statistically analysed by using one-way analysis of variance and completely randomized design respectively. Wherever the significant result was obtained the critical difference test was used. Parameters for comparison between treatments were analysed by student t- test.

RESULTS AND DISCUSSION

Physical characteristics of *paddu* batter of little millet and rice are presented in Table 1. From the data it was found that the initial volume (20 ml) of little millet batter increased to 46.37 ml there by the percent increase in volume being 131.83 per cent similarly for rice the percent increase was found to be 111.67. The increase in batter volume after fermentation was more in little millet when compared to rice. The increase in the volume of batter between rice and millet was found to be statistically significant ($p \leq 0.01$). Increase in volume of the both batters between before and after fermentation was statistically significant. The interaction between cereals and fermentation was significant for increase in volume and per cent increase in volume. The weight of the little millet batter before fermentation was 20.72 and after fermentation the weight was 20.57 and the weight of rice batter before and after fermentation was 20.65 and 20.60 g respectively. The difference in the weight of the batters before and after fermentation and between cereals was not significant. The interaction between cereals and fermentation was found to be non significant. Per cent increase in volume of little millet batter was significantly higher than the rice batter. Significant difference in the per cent increase in volume of batters between cereals and between fermentation was observed. The interaction between cereals and fermentation was significant. Table 1 represents the bulk density and specific gravity of little millet *paddu* batter in comparison to rice. When the bulk density based on weight and volume of the batter was calculated it was found that the bulk density reduced from 1.04 to 0.44 g/ml for little millet batter and it reduced from 1.03 to 0.49 g/ml for rice batter after fermentation. While the difference in the bulk densities between little millet and rice batters with before and after fermentation were found to be statistically significant. The bulk density between before and after fermentation with little millet and rice batter was also significant. Specific gravity of the batters reduced from 1.05 to 0.45 for little millet batter and it reduced from 1.05 to 0.49 for rice batter after fermentation. The difference in the specific gravity between little millet and rice batters with before and after fermentation was found to be significant. The difference in the specific gravities of the two batters between before and after fermentation was found to be

TABLE 1: Physico- chemical characteristics of little millet batter in comparison to rice batter

Cereal	Volume (ml)			Weight (g)			Bulk density (g/ml)			Specific gravity (g/g)			pH			Per cent titratable acidity		
	BF	AF	Mean	BF	AF	Mean	BF	AF	Mean	BF	AF	Mean	BF	AF	Mean	BF	AF	Mean
Little millet	20.00	46.37	33.18	20.72	20.57	20.64	1.04	0.44	0.74	1.05	0.45	0.75	6.67	5.07	5.87	0.53	0.98	0.75
Rice	20.00	42.33	31.17	20.65	20.60	20.63	1.03	0.49	0.76	1.05	0.49	0.77	6.57	5.57	6.07	0.58	0.91	0.75
Mean	20.00	44.35	32.18	20.69	20.59	20.64	1.03	0.47	0.75	1.05	0.47	0.76	6.62	5.32	5.97	0.56	0.94	0.75
Between cereals (C)		SEm	CD		SEm	CD		SEm	CD		SEm	CD		SEm	CD		SEm	CD
		0.20	0.64**		0.04	NS		0.003	0.009**		0.003	0.010**		0.08	NS		0.04	NS
Between BF and AF (F)		0.20	0.64**		0.04	NS		0.003	0.009**		0.003	0.010**		0.08	0.28**		0.04	0.13**
C x F		0.28	0.91**		0.05	NS		0.004	0.012**		0.004	0.014**		0.12	0.39**		0.06	NS

Note: Values are mean of three replications, SEm-standard error of mean, CD-Critical difference. BF- Before fermentation, ** Significant @1%, NS- Non Significant. C x F- Cereal x between before and after fermentation.

significant. The interaction between cereals and fermentation was found to be significant for both bulk density and specific gravity.

Changes in pH and per cent titratable acidity of little millet batter in comparison to rice batter is also presented in Table 1. The pH of the little millet batter reduced from 6.67 to 5.07 and for rice from 6.57 to 5.57 with increase in the total titratable acidity. However, the decrease in pH between little millet and rice batters with before and after fermentation was found to be non significant. The decrease in pH between before and after fermentation with little millet and rice batter was statistically significant. The interaction between cereal and fermentation was found to be significant. This is attributed to the increased addition of little millet *paddu*. Pulse, the leguminous component generally in preparation of *idli* batter, serves not only as an effective substrate but also provides the maximum number of microorganisms for fermentation. Black gram soaked in water has higher concentration of soluble nutrients to support the growth of microorganisms and results in formation of air pockets and leavening action (Balasubramanian and Viswanathan 2007). The higher increase in volume of batter and decrease in pH of little millet batter might be due to the nutrient composition of little millet and it needs further research in this line. Generally all most all millets are commonly and traditionally used for fermented foods.

The total titratable acidity of the batter increased after fermentation for both little millet and rice batters. Before fermentation the titratable acidity of millet and rice batter was 0.53 and 0.58, whereas after fermentation it was 0.98 to 0.91 respectively. While, the increase in titratable acidity of batters between before and after fermentation with little millet and rice was found to be significant. The titratable acidity of batter prepared with little millet and rice was not significant. The interaction between cereals and fermentation was found to be non significant.

Table 2 depicts the physical characteristics of little millet *paddu* in comparison to rice *paddu*. The total weight of little millet *paddu* was more (125.67 g) when compared to rice *paddu* (124.00 g), however there was no significant difference was found in the total weight of the little millet and rice *paddu*. Further the total volume of little millet *paddu* was significantly more (99.00 ml) when compared to rice *paddu* (185.33ml). The average weight (13.46 g) and volume (22.11 ml) of single little millet *paddu* were more when compared to weight (13.78 g) and volume (20.59 ml) of single rice *paddu*. There was no significant difference was found between average weights of little millet and rice *paddu*. While the difference in average volume of little millet and rice *paddu* was highly significant ($p \leq 0.01$). The bulk density of the little millet *paddu* (0.63 g/ml) was significantly ($p \leq 0.01$) lower than the bulk density of rice *paddu* (0.67 g/ml).

Proximate composition of *paddu* prepared from little millet (*little millet*) and rice are presented in Table 3. The moisture, protein, fat, ash, crude fibre and carbohydrate content of *little millet paddu* were 47.80, 14.50, 5.01, 2.87, 1.53 and 28.29 g/100g respectively. Significant variation in the nutrient composition of *little millet paddu* was observed as compared to rice *paddu*. Little millet *paddu* was nutritionally superior with respect to protein, fat, ash and crude fibre. There was no significant difference was observed in energy of the both *little millet paddu* (216 kcal/100g) and rice *paddu* (219 kcal/100g). According to the nutritive value of Indian foods, the nutrient composition of little millet is higher than rice (Gopalan *et al.*, 2007).

The mean sensory scores of *paddu* prepared from little millet and rice are presented in Table 4. The mean sensory scores for different quality attributes ranged from 7.40 to 7.93. The overall acceptability scores of rice *paddu* was higher (7.80) than *little millet paddu* (7.40). The sensory scores of *paddu* prepared from rice were higher than *little millet paddu* for texture (7.80), flavour (7.87) and taste (7.87).

TABLE 2: Physical characteristics of little millet *paddu* in comparison to rice *paddu*

<i>Paddu</i> Sample	No. of <i>Paddu</i>	Total weight of <i>paddu</i> (g)	Total volume of <i>paddu</i> (ml)	Average weight of 1 <i>paddu</i> (g)	Average volume of 1 <i>paddu</i> (ml)	Bulk density of <i>paddu</i> (g/ml)
Little millet	9	125.67	199.00	13.96	22.11	0.63
Rice	9	124.00	185.33	13.78	20.59	0.67
t-value	NS	2.5 ^{NS}	4.9**	2.5 ^{NS}	4.9**	3.76*

Note: Values are means of three replications. NS-Non significant, * Significant @ 5%, ** Significant @ 1%.

TABLE 3: Proximate composition of little millet and rice *paddu*

<i>Paddu</i> sample	Proximate composition (%)						
	Moisture	Protein	Fat	Ash	Crude fibre	Carbohydrate	Energy (Kcal/ 100 g)
Little millet	47.80	14.50	5.01	2.87	1.53	28.29	216
Rice	48.73	12.17	4.89	1.67	1.06	31.47	219
t-value	7.21**	15.90**	0.45 ^{NS}	16.11**	3.15*	19.30**	0.90 ^{NS}

Note: values are means of three replications.*Significant @ 5 %, ** Significant @ 1%, NS- non significant.

where as for appearance (7.93) and colour (7.89), sensory scores were higher for *paddu* prepared from *little millet* than the rice *paddu*. However there was no significant difference between the scores of *little millet* and rice *paddu*. Higher sensory scores of rice *paddu* for taste and flavour than little millet *paddu* were attributed to the less sourness of the product which was confirmed by the pH of the batter (Table 1).

The population of bacteria count of little millet and rice batter at different period of fermentation are presented in Table 5. The total bacterial counts were higher in millet batter during progress of fermentation from 0 h to 24 h than the rice batter. The total bacteria count increased up to 18 h of fermentation there after it stabilized with slight decrease after 24 h of fermentation in both rice and millet batter. The highest increase in bacterial count for little millet batter was after 18 h (59.0×10^{11}) of fermentation whereas highest bacterial count for rice was at 12 h (13.1×10^{10}) of fermentation. Increase in the bacterial count between little millet and rice batter with varying hours of fermentation and between fermentation hours with little millet and rice batter was statistically significant ($p < 0.01$). Table 5 depicts the population of yeast counts in little millet and rice batter at different periods of fermentation. Yeast counts were highest (12.9×10^{14}) after 12 h of fermentation for little millet batter whereas yeasts counts were highest (23×10^{12}) for rice after 18 h of fermentation in rice batter. The increase in yeast count was found to be statistically significant with the increase in fermentation between and little millet rice batter. The population of fungi of little millet and rice batter at different period of fermentation are presented in Table 5. Fungi counts were least when compared to other microorganisms. The fungal count increased up to 18 h of fermentation there after it stabilized up to 24 h. The highest fungal count was found at 12 h (16×10^3) in little millet batter whereas the highest fungal count was found at 18 h (36×10^4) in rice batter of fermentation respectively. The increase in fungi between rice and little millet with increasing fermentation was found to be significant ($p < 0.01$).

Table 6 depicts the population of *L. mesenteroides* counts of little millet and rice batter at different periods of fermentation. In general, the *L. mesenteroides* counts were more in rice batter when compared to little millet batter. The highest count (52×10^{11}) of *L. mesenteroides* in rice batter was found after 18 h of fermentation whereas for little millet batter highest number (88×10^{10}) of count was

observed after 12 h of fermentation. The *L. mesenteroides* count increased up to 12 h of fermentation there after it stabilized with slight decrease in count in little millet batter. The increase in count between little millet and rice with increase in fermentation as well as between fermentation hours with little millet and rice was found to be highly significant. The population of *Lactobacillus sp.* count of little millet and rice batter at different period of fermentation are presented in Table 6. The *Lactobacillus sp.* counts were more in little millet batter than the rice batter. The *Lactobacillus sp.* count were higher after 6 h (10.8×10^{12}) of fermentation in little millet batter there after it stabilized with slight decrease in the count, whereas in rice batter the *Lactobacillus* counts were higher after 18 h (52.0×10^{11}) of fermentation there after it reduced. The increase in the *Lactobacillus* count between rice and little millet batter with increase in fermentation as well as the increase in count between fermentation hours with rice and little millet batter was found to be statistically highly significant. The interaction between fermentation hours and cereals was highly significant. Chavan and Kadam (1989) have indicated that the microorganisms involved in the natural fermentation of cereals are essentially surface flora of seeds. Table 6 depicts the population of *E coli* of little millet and rice batter at different periods of fermentation. *E coli* counts were higher in little millet batter than the rice batter. The *E coli* count increased up to 6 h of fermentation there after it was not detected at 12 h of fermentation in both rice and little millet batter. The *E coli* counts were significant between rice and little millet batter as well as between fermentation hours. The interaction between fermentation hours and cereals was also significant. The high content of tannins in millets and lactic acid bacteria is known to inhibit growth of *E coli* and pathogenic bacteria (Nout and Rombouts 1992). The presence of *E coli* might be due to the poor post harvest techniques followed by the farmers.

Table 7 depicts the microbiological analysis of *paddu* prepared from little millet and rice. Among the micro organisms tested, except yeast (1.0×10), bacteria, *L. mesenteroides*, *Lactobacillus sp.* and *E coli* were not observed in *paddu* prepared from little millet. Similarly, except bacteria (12×10^3), all other microflora tested were absent in *paddu* prepared from rice). *E coli* count were not found in both the *paddu* as the batter was shallow fat fried

TABLE 4: Sensory scores of little millet *paddu* in comparison to rice *paddu*

<i>Paddu</i> samples	Sensory attributes					
	Appearance	Colour	Texture	Flavour	Taste	Overall acceptability
Little millet	7.93 ± 0.35	7.87 ± 0.55	7.47 ± 0.41	7.53 ± 0.41	7.47 ± 0.27	7.40 ± 0.26
Rice	7.87 ± 0.69	7.80 ± 0.89	7.80 ± 0.60	7.87 ± 0.55	7.87 ± 0.55	7.80 ± 0.60
t-value	0.25 ^{NS}	0.22 ^{NS}	1.28 ^{NS}	1.32 ^{NS}	1.71 ^{NS}	1.67 ^{NS}

Note: Means of 15 panellists. Sensory scores were based on 9 point hedonic scale ^{NS} non Significance

TABLE 5: Population of bacteria, yeast and fungi of little millet and rice batter at different period of fermentation

Fermentation hours	Bacteria			Yeast			Fungi		
	Little millet	Rice	Mean	Little millet	Rice	Mean	Little millet	Rice	Mean
0	15.0 x 10 ⁵	28.5 x 10 ⁴	89.2 x 10 ⁴	41.0 x 10 ⁴	31.0 x 10 ³	22.0 x 10 ⁴	40.0 x 10 ³	36.0 x 10 ²	21.8 x 10 ³
6	92.0 x 10 ⁸	27.6 x 10 ⁵	46.0 x 10 ⁸	92.0 x 10 ¹⁰	23.5 x 10 ⁶	46.0 x 10 ¹⁰	12.2 x 10 ⁴	56.0 x 10 ³	89.0 x 10 ³
12	40.0 x 10 ⁸	13.1 x 10 ¹⁰	67.5 x 10 ⁹	12.9 x 10 ¹⁴	15.6 x 10 ⁸	64.5 x 10 ¹³	16.0 x 10 ³	26.0 x 10 ⁴	13.8 x 10 ⁴
18	59.0 x 10 ¹¹	86.0 x 10 ⁹	29.9 x 10 ¹¹	90.0 x 10 ¹¹	23.0 x 10 ¹²	16.0 x 10 ¹²	30.0 x 10 ⁴	36.0 x 10 ⁴	33.0 x 10 ⁴
24	58.0 x 10 ⁸	32.0 x 10 ⁷	30.6 x 10 ⁸	59.0 x 10 ⁸	17.2 x 10 ⁹	11.6 x 10 ⁹	0.17	31.0 x 10 ⁴	15.5 x 10 ⁴
Mean	11.8 x 10 ¹¹	43.5 x 10 ⁹	61.3 x 10 ¹⁰	25.9 x 10 ¹³	46.0 x 10 ¹¹	13.2 x 10 ¹³	95.6 x 10 ³	197920	14.67 x 10 ⁴
	SEm	CD		SEm	CD		SEm	CD	
Between fermentation hours (F)	158645307	468003305.6**		12.91 x 10 ¹¹	380.843 x 10 ^{10**}		2330.957	6876.318**	
Between Cereal (C)	100336102	295991279.6**		81.6497 x 10 ¹⁰	240.866 x 10 ^{10**}		1474.227	4348.965**	
F x C	224358345	661856622**		182.574 x 10 ¹⁰	538.594 x 10 ^{10**}		3296.471	9724.582**	

TABLE 6: Population of *Leuconostoc mesenteroids*, *Lactobacillus* sp. and *E. coli* of little millet and rice batter at different periods of fermentation

Fermentation hours	<i>Leuconostoc mesenteroids</i>			<i>Lactobacillus</i> sp.,			<i>E. coli</i>		
	Little millet	Rice	Mean	Little millet	Rice	Mean	Little millet	Rice	Mean
0	32.0 x 10	90.0 x 10 ²	46.6 x 10 ²	16.0 x 10 ²	11.0 x 10 ¹	85.5 x 10 ¹	14.4 x 10 ²	53.8 x 10 ¹	990.34
6	12.3 x 10 ¹⁰	13.2 x 10 ⁸	62.2 x 10 ⁹	10.8 x 10 ¹²	12.1 x 10 ³	54.0 x 10 ¹¹	10.9 x 10 ³	46.8 x 10 ²	57313.43
12	88.0 x 10 ¹⁰	48.0 x 10 ¹¹	2.84 x 10 ¹²	92.0 x 10 ¹⁰	85.0 x 10 ⁵	46.0 x 10 ¹⁰	7.1 x 10	7.1 x 10	7.1 x 10
18	63.0 x 10 ⁹	52.0 x 10 ¹¹	26.3 x 10 ¹¹	84.0 x 10 ⁹	52.0 x 10 ¹¹	26.4 x 10 ¹¹	7.1 x 10	7.1 x 10	7.1 x 10
24	40.0 x 10 ⁸	73.0 x 10 ⁷	23.6 x 10 ⁷	34.0 x 10 ⁸	14.0 x 10 ⁷	17.7 x 10 ⁸	7.1 x 10	7.1 x 10	7.1 x 10
Mean	2.14 x 10 ¹¹	2.0 x 10 ¹²	11.0 x 10 ¹¹	23.6 x 10 ¹¹	10.4 x 10 ¹¹	17.0 x 10 ¹¹	22276.32	1046.04	11.6 x 10 ³
	SEm	CD		SEm	CD		SEm	CD	
Between Fermentation hours (F)	64562631.09	190459619**		12910589968	38.1 x 10 ^{9**}		587.52	1733.19**	
Between Cereal (C)	40832993.2	120457240**		8165374047	24.1 x 10 ^{9**}		371.58	1096.17**	
F x C	91305348.51	269350576**		18258331432	53.9 x 10 ^{9**}		830.88	2451.10**	

Note: values are means of three replications. ** Significant @ 1%.

TABLE 7: Microbiological analysis of freshly prepared *paddu* from little millet and rice

Samples	Bacteria	Yeast	Fungi	<i>Leuconostoc mesenteroides</i>	<i>Lactobacillus</i>	<i>E. coli</i>
Little millet <i>paddu</i>	Absent	1 X10	Absent	Absent	Absent	Absent
Rice <i>paddu</i>	12 X10 ³	Absent	Absent	Absent	Absent	Absent

at 160 to 170° C. This is in agreement with observations in millet products (Onyango *et al.*, 2004; Gassem *et al.*, 1999). The fermentation of idli demonstrates a leavening action caused by the activity of the hetero fermentative lactic acid bacterium, *L. mesenteroides* (Mukherjee *et al.* 1965 and Venkatasubbaiah *et al.* 1984).

CONCLUSION

The physical characteristics, microbial population of little millet batter and physical characteristics of *paddu*

were higher than rice. Similarly the decrease in weight and pH of batter and increase in titratable acidity was higher in little millet. The nutrient composition of *paddu* prepared from little millet was higher than rice *paddu* and did not show significant difference in the scores of sensory attributes. Thus the neglected millets can be introduced as fermented and nutritious food in which lactic acid fermentation plays a key role in food safety and acceptability of the product in food catering centres.

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