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Research Article

Evaluation of Fermentation Quality of Nutri Rich Aerobic Rice Genotypes

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Keywords

- Aerobic rice; Fermentation quality; Titrable acidity; Batter volume; Fermented product

Abstract

Fermentation is one of the oldest and economical food processing method to improve digestability of foods. Six nutri rich aerobic rice varieties (HPR-565, HPR-801, HPR-814, HPR-930, HPR-1241, HPR-1630) and one check variety (HP-9) which are high in protein (RIL'S) were procured from the, MASLAB, Department of Genetics and Plant Breeding, UAS, GKVK, Bengaluru and analyzed for fermentation quality. The milled rice and dehusked black gram dhal (urad dhal) in the ratio of 4:1 (w/w) were washed thoroughly and soaked separately in twice the volume of water for 8 hours at room temperature. They were ground separately and mixed, kept for fermentation at room temperature (28 °C) for 8 hours. Increases in batter volume, Batter pH, Titrable acidity were assessed as per standard procedures. Range of pH of fresh batter was 5.12 to 6.14 which had decreased to a range of 4.22 to 4.38 after 8 hours fermentation. Similarly pH of check variety also decreased from 6.14 to 4.50. There was significant difference observed in aerobic rice genotypes ($p<0.05$) with respect to pH variability. The change in pH may be attributed to the concomitant increase in titrable acidity in terms of lactic acid/100ml of substrate. The titrable acidity of freshly ground rice batter ranged from 0.02 to 0.07g increased to a range of 0.19 (HPR 930, HPR 1241 and HPR 1630) to 0.22g (HPR 814) after 8 hours of fermentation. Check variety had an increase from 0.07 to 0.21/100g. The batter volume increased for all samples with maximum rise in HPR 814 (4.93 ml) and HPR 565 (3.03 ml) followed by HPR 930 (1.83 ml). Check variety (HP 9) showed 4.0 ml rise in volume. HPR 565 and HPR 814 and also check variety were found to be better for fermented product preparations such as idly, and dosa *etc.*

INTRODUCTION

Rice (*Oryza sativa* L.) is a monocotyledon plant belonging to the grass family Poaceae. It is a major staple cereal valued for human food contributing to calories consumption and dietary component for more than one third of the world's population. India is the largest rice growing country accounting for about 2/3rd of world acreage under rice crop. World production of rice was 745.2 million tonnes with area of 162.4 million hectares [1]. India having a total rice cultivation area of 433.88 lakh hectare with the production of 104.32 million tonnes of rice during the 2015-16 [2]. Rice is consumed primarily in milled or polished form, containing only the starchy endosperm. Dehusked rice is commonly recognized as peasant food and only consumed by the elderly among Asians [3] (Plate 1). In recent times, unpolished rice has been acclaimed as a rich source of important bioactive compounds and nutraceuticals with numerous potential health functions. The major bioactive molecules reported to present in the rice grain include the phenolic acids, polyphenols, oryzanol, tocopherol, tocotrienols and sterols [4]. Asia has the largest population of malnourished people particularly children and therefore the production of rice should keep on par with the population in order to overcome the existing energy gap. Grain quality has become a major concern for domestic consumption and international rice trade. Consumer preferences include grain appearance, size and shape, better milling, cooking behavior, taste, tenderness, and cooked rice flavour. Preferences for cooking quality vary across different countries around the world. Varietal enhancement is therefore the most economical way to improve the quality of grain without affecting the output. Increasing water scarcity and competition for the same water from non-agricultural sectors, as the CGIAR (Consultative Group for International Agricultural Research) Challenge Program on Water and Food puts it; there is an urgent need to improve crop water productivity to ensure adequate food for future generations with the same or less water available to agriculture. Aerobic rice, the term given by Bouman [5], is high yield rice grown in unpuddled, unflooded, aerobic (unsaturated) soil (i.e., oxygen soil) under irrigation and in areas with dwindling water supply. It is considered as environment friendly method as it does not produce methane and also less labor intensive.

Aerobic rice has more balanced amino-acid profile. High-protein rice has the potential to enhance nutrition in poor rural families where rice serves as the staple food [6]. Enrichment of protein in rice would have a positive impact to enhance the protein availability which is essential to combat protein energy malnutrition and hidden hunger which is still continues to be major health burden in developing countries. Researchers have

Initial (zero hours)

Final (After 8 hours)

Plate 1 Paddy and rice grain of nutri rich aerobic rice genotypes

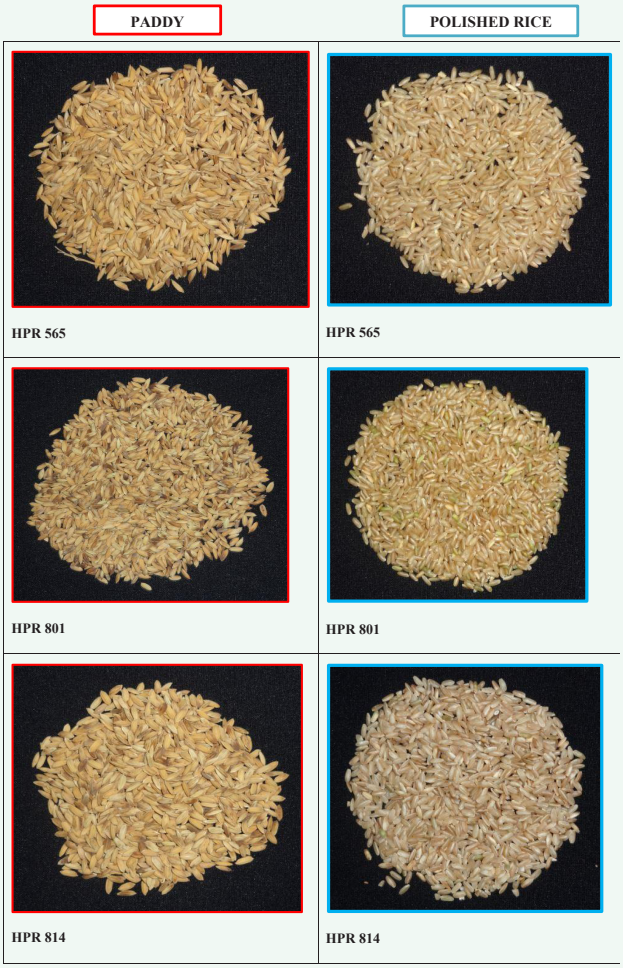

Plate 1a Paddy and rice grain of nutri rich aerobic rice genotypes

been trying to boost the protein content in rice for five decades through plant breeding interventions by evolving high protein rice genotypes. Total grain protein (TGP) content is the prime most important parameter in rice quality production. TGP is complex trait controlled by several genes which is interrelated to grain yield. Hence long term research of breeding attempts on segregating generations with protein rich local landrace parents with popular local rice variety to boost the total protein content under aerobic situation was carried out in the Department of Genetics and Plant Breeding, UAS,GKVK, Bengaluru. The protein content was found to increase around 4.5 per cent from present cultivating varieties without affecting the regular yield as much of BPT 5204 along with medium to fine quality grains containing moderate to higher content of micronutrients (iron and zinc) in the developed Recombinant Inbred Lines(RIL'S). Such research outputs lead to high quality grain production to reach the needy population.

Rice is considered as divine food in India with socio cultural sentiments but when consumed principally as a whole grain, the texture and flavor plays important role. Consumer preference of rice varieties is mainly based on grain and cooking qualities. The grain quality depends on its physicochemical characteristics such as milling efficiency, percentage head rice yield, broken percentage, chalkiness of endosperm, dimensional properties of grain *etc.* The economic value of rice depends on its cooking quality such as water uptake ratio, grain elongation ratio, percent curled grains and cooking time. Rice protein is superior in lysine content to wheat, corn and sorghum [7]. Fermented cereals have been noted for their superior nutritional value, shelf-life and digestibility compared to the unfermented counterpart [8]. Use of rice along with pulses *(black gram, bengal gram*) is necessary as a source of mixed natural microflora needed for efficient fermentation during preparation of *idli, dosa, dhokla* batters. A group of microbes (natural or from starter culture) grow well in cereal based foods, biochemically and organoleptically transform the substrates, produce different metabolites, destroys or detoxifies the harmful products (phytates, tannins, and polyphenols) and enrich the food with different micro-nutrients (vitamins, minerals, amino acids, etc.), health beneficial edible microbes (i.e. probiotics), fermentable sugars (i.e. prebiotic), dietary fibers, phytochemicals and digestive enzymes. . Rice, being the most dominant cereal crop in most of the countries can improve the health condition of millions of people who consume it.

Thus, information on the nutritional aspect and sensory features of various aerobic rice varieties (genotypes) help to recognize suitable varieties for table purposes or preparation of food products for consumer preference. There is a need to assess the quality of these nutri rich aerobic rice varieties in comparison with the released check variety HP-9 (Paustic-9) with respect. Hence, the study was undertaken with the following objective. Evaluation of fermentation quality and develop food products from nutri rich aerobic rice genotypes.

MATERIAL AND METHODS

The study deals with the details of the materials and methods used to accomplish the research topic entitled "evaluation of fermentation quality of nutri rich aerobic rice genotypes" in the Department of Food Science and Nutrition, Gandhi Krishi Vignana Kendra, UAS, Bengaluru, during 2017-2019.

Batter Fermentation Quality

Preparation of rice batter: The milled rice and dehusked black gram dhal (urad dhal) in the ratio of 4:1 (w/w) were washed thoroughly and soaked separately in twice the volume of water for 8 hours at room temperature. They were ground separately in an electrical mixer, black gram dhal being ground to a fine paste and rice ground to a coarse consistency. Afterwards both ingredients were mixed. The batter was then transferred to a glass tube, covered with a lid and fermented at room temperature (28°C) for 8 hours [9].

Analysis of rice batter

Increases in batter volume: Prepared rice batter (20 ml) was transferred to a glass tube covered with a lid and fermented at room temperature (28°C) for 8 hours. Difference in batter before and after fermentation were determined as increase in batter volume [10].

Batter pH: The pH of the batter sample was measured before and after fermentation using digital pH meter (Digital pH meter type MK-VI). Standard buffer solutions of pH 4.0 and 7.0 were used to calibrate the instrument.

Titrable acidity: Known amount of batter sample (5ml) was taken in a 100 ml beaker, kept in boiling water bath at 70°C, cooled and titrated against 0.1 N NaOH using 2 drops of phenolphthalein indicator. Appearance of light pink colour indicates the end point. Total titrable acidity was expressed in terms of lactic acid per 100 ml of substrate [11].

$$Titrable\ acidity\,(\%) = \frac{\text{Titre value} \times \text{ Normality of NaOH} \times 90.01 \times 100}{\text{ml of sample taken} \times 1000}$$

Development of food products: Rice varieties namely HPR-565, HPR-801, HPR- 814, HPR-930, HPR-1241 and HPR-1630 were utilized for development of food products *Dosa and Idly*. The HP-9(Check variety) rice variety served as a control. The grain of the eight rice varieties were cleaned and made free of dust, dirt and foreign materials prior to development of food products.

Organoleptic evaluation of the developed food products: All the food products were subjected to sensory evaluation with respect to colour, appearance, aroma, texture, taste and overall acceptability by a semi-trained taste panel comprising of 10 judges using the 9-point Hedonic Rating scale. Based on mean scores of sensory evaluation obtained after feeding to the judges, the most acceptable products were selected for further studies.

Statistical Analysis

Results were expressed as mean ± SEM (standard error mean) and as data analysis were carried out using the statistical package for social science (SPSS) (Version 17.0 for windows, SPSS Inc., Chicago, USA). The statistical method used was student's t-test (two tailed) and analysis of variance (ANOVA) analysis. Difference was considered significant at a probability level of 5 percent or 1 percent.

RESULTS AND DISCUSSION

Batter fermentation quality characteristics of nutri rich aerobic rice genotypes

As the rice is main ingredient for most of the fermented dietary products of south India, it was of interest to study the fermentation efficiency of rice genotypes. The prepared aerobic rice batter was studied for fermentation quality for 8 hours duration assessing the parameter such as rise in batter volume, pH and titrable acidity as depicted in Table 1. Hence, all the rice genotypes mixed with black gram (4:1 proportion) soaked and ground to batter to prepare batter and further analysed for fermentation quality.

The batter volume increased for all the samples during fermentation over a period of 8 hours [Figure 2]. Maximum rise in batter volume was found in HPR 814 (4.93 ml) and HPR 565 (3.03 ml) followed by HPR 930 (1.83 ml), HPR 1630 (1.76 ml), HPR 801 (1.50 ml) and least was in HPR 1241 (1.23 ml). Check variety (HP 9) showed 4.0 ml rise in volume. It can be concluded by findings that two experimental varieties (HPR 565 and HPR 814) and also check variety were better for fermented product preparations such as idli, dosa and ediappam *etc.*

Range of pH of fresh batter was 5.12 to 6.14 which had decreased to a range of 4.22 to 4.38 after 8 hours fermentation. Similarly pH of check variety also decreased from 6.14 to 4.50. There was significant difference observed in aerobic rice genotypes ($p<0.05$), with respect to pH variability. The change in pH may be attributed to the concomitant increase in titrable acidity in terms of lactic acid/100ml of substrate.

The titrable acidity of freshly ground rice batter ranged from 0.02 to 0.07g increased to a range of 0.19 (HPR 930, HPR 1241 and HPR 1630) to 0.22g (HPR 814). Check variety had an increase from 0.07 to 0.21/100g after 8 hours of fermentation [12], reported that with utilization of sugars during fermentation duration, organic acids were produced which might also have contributed to the increase in acidity. Similar study was reported

Table 1: Batter fermentation quality of nutri rich aerobic rice genotypes after 8 hours

Rice Genotypes	Batter volume (ml)		Increase in batter volume (ml)	pH		Titrable acidity (gram in terms of lactic acid/100ml substrate)	
	Initial	Final		Initial	Final	Initial	Final
HPR 565	20	23.03±0.05^{c}	3.03	5.62±0.01^{b}	4.22±0.02^{d}	0.06±0^{b}	0.20±0^{c}
HPR 801	20	21.50±0.5^{d}	1.50	5.61±0.01^{b}	4.31±0^{c}	0.05±0^{c}	0.20±0^{d}
HPR 814	20	24.93±0.60^{a}	4.93	5.62±0^{b}	4.38±0.02^{b}	0.06±0^{b}	0.22±0^{a}
HPR 930	20	21.83±0.28^{d}	1.83	5.61±0.01^{b}	4.32±0.01^{c}	0.05±0^{c}	0.19±0^{d}
HPR 1241	20	21.23±0.40^{d}	1.23	5.61±0.01^{b}	4.32±0.02^{c}	0.07±0^{a}	0.19±0^{d}
HPR 1630	20	21.76±0.25^{d}	1.76	5.12±0.01^{c}	4.23±0.02^{d}	0.02±0^{d}	0.19±0^{d}
HP 9	20	24.00±0.5^{b}	4.00	6.14±0.01^{a}	4.50±0.01^{a}	0.07±0^{a}	0.21±0^{b}
Mean	20	22.61	2.61	5.62	4.32	0.05	0.20
F value	-	*	-	*	*	*	*
SEm±	-	0.23	-	0.007	0.01	0.001	0.001
CD @ 5%	-	0.71	-	0.028	0.03	0.003	0.005

* Significant (p<0.05) NS – Non-significant HP 9 – Check variety
Means in the same column followed by different superscript letters differ significantly.

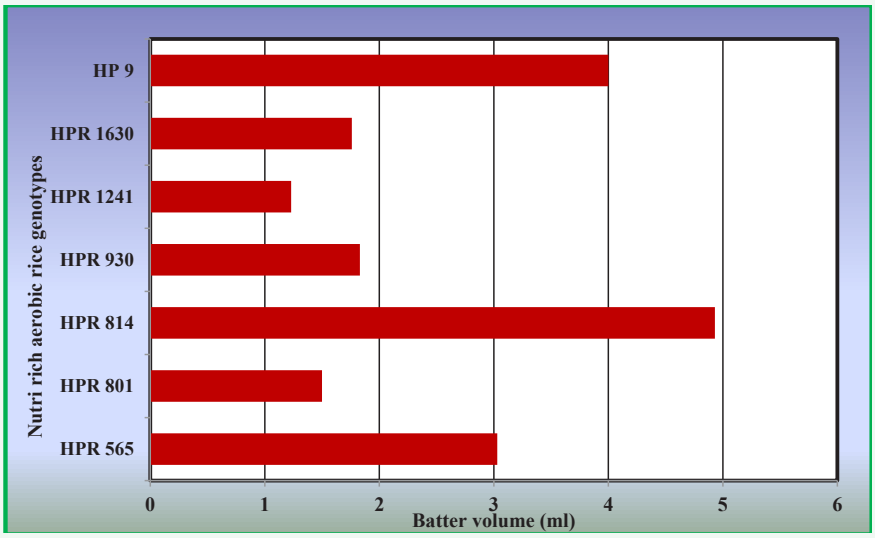

Figure 1 Increase in batter volume during fermentation after 8 hours in nutri rich aerobic rice genotyp.

by [13]. The pH and percentage of titrable acidity of batter during fermentation for different blend ratio (rice and black gram) ranged between 4.21 to 5.9 and 0.44 to 0.91 respectively. There was an increasing trend of titrable acidity level as the pH value was decreasing. This is mainly associated with development of *Streptococcus faecalis* producing lactic acid which reduces the pH and production of carbon dioxide which leavens the batter [14].

Black gram soaked in water has more concentration of soluble nutrients to support the growth of lactic acid bacteria. The role of lactic acid bacteria is to reduce the pH of batter to an optimum level (4.4 to 4.5) for yeast activity [15]. The study revealed that HPR 814, HPR 565 and check variety are having good fermentation quality and suitable for fermented rice based products.

Product development and their organoleptic evaluation

All the seven rice varieties HPR-565, HPR-801, HPR- 814, HPR-930, HPR-1241, HPR-1630 and HP-9(Check variety) were used for the preparation of food product Idli and Dosa and subjected to sensory evaluation with respect to colour, appearance, aroma, texture, taste and overall acceptability.

Idli: The data in Table 2 indicated that *Dosa* prepared from seven different rice varieties namely check variety (HP 9) Dosa, HPR-565 *Idli* and HPR-814 *idli* were fall in the category of "liked very much" in overall acceptability whereas the aroma of control *idli* was "liked moderately" and taste of HPR-814 *idli* was "liked slightly:" by panel of experts.

Mean scores of *idli* prepared using different rice varieties HPR-865, HPR-814 and HP-9 showed that the colour, appearance of control, taste texture and overall acceptability idli was liked very much, whereas control *idli* was liked moderately in terms of appearance, aroma, and texture, and taste by the judges.

Table 2: Organoleptic acceptability of *Idli prepared* from different rice varieties

Variety	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
HPR 565	8.40±0.27	8.00±0.24	8.80±0.23	7.95±0.36	7.70±0.35	8.86±0.35
HPR 801	7.90±0.23	7.30 ±0.16	7.50±0.21	7.30±0.26	7.50±0.32	7.76±0.22
HPR 814	8.70±0.27	8.12±0.33	8.16±0.26	8.40±0.32	7.20±0.37	8.52±0.25
HPR 930	7.70±0.24	7.90±0.25	7.50±0.25	7.20±0.12	7.40±0.16	7.88±0.16
HPR 1241	7.30±0.19	7.70±0.23	7.90±0.24	7.20±0.21	7.90±0.22	7.60±0.28
HPR 1630	7.50±0.15	7.30±0.24	7.70±0.36	7.90±0.28	7.96±0.25	7.46±0.15
Check variety HP 9	8.10±0.1	7.90±0.22	7.80±0.13	7.90±0.3	8.18±0.15	8.50±0.23
CD(P<0.05)	**0.89**	**0.79**	**0.76**	**0.73**	**0.68**	**0.78**

Values are mean ± SE of three independent determinations

Table 3: Organoleptic acceptability of *Dosa* prepared from different rice varieties

Variety	Colour	Appearance	Aroma	Texture	Taste	Overall Acceptability
HPR 565	8.50±0.27	8.00±0.24	7.80±0.23	7.90±0.36	7.90±0.35	8.86±0.35
HPR 801	7.50±0.23	7.20±0.16	7.30±0.21	7.20±0.26	7.30±0.32	7.56±0.22
HPR 814	8.70±0.27	8.12±0.33	7.86±0.26	8.50±0.32	7.90±0.37	8.52±0.25
HPR 930	7.60±0.24	7.30±0.25	7.40±0.25	7.10±0.12	6.40±0.16	7.08±0.16
HPR 1241	7.60±0.19	7.80±0.23	7.70±0.24	7.50±0.21	7.80±0.22	7.70±0.28
HPR 1630	7.20±0.15	7.20±0.24	7.40±0.36	7.30±0.28	7.36±0.25	7.36±0.15
Check variety HP 9	8.10±0.1	7.80±0.22	7.80±0.13	7.90±0.3	8.18±0.15	8.50±0.23
CD(P<0.05)	**0.87**	**0.76**	**0.78**	**0.74**	**0.62**	**0.78**

Values are mean ± SE of three independent determinations

Mean scores of *idli* prepared using HPR-801, HPR-930, HPR-1241; rice variety showed that the aroma, texture and taste was liked moderately, whereas HPR-930 *dosa* was liked slightly in taste by the judges. The results obtained from organoleptice evaluation revealed that the mean organoleptic scores of *idli* are comparable with ranges reported earlier by Beniwal [16,17].

Dosa: The data in Table 3 indicated that *Dosa* prepared from seven different rice varieties namely check variety (HP 9) Dosa, HPR-565 *Dosa* and HPR-814 *Dosa* were fall in the category of "liked very much" in overall acceptability whereas the aroma of control *Dosa* was "liked moderately" and taste of HPR-814 *Dosa* was "liked slightly:" by panel of experts.

Mean scores of *dosa* prepared using different rice varieties showed that the aroma of control *dosa* was liked very much, whereas control *dosa* was liked moderately in terms of colour, appearance, texture, taste and overall acceptability by the judges. The acceptability scores of *dosa* prepared from HPR-865 and HPR-814 rice varieties were liked very much in terms of colour, appearance, aroma, texture, taste and overall acceptability by the judges.

Mean scores of *dosa* prepared using HPR-801, HPR-930, HPR-1241, rice variety showed that the aroma, texture and taste was liked moderately, whereas HPR-930 *dosa* was liked slightly in taste by the judges. The results obtained from organoleptic evaluation revealed that the mean organoleptic scores of *dosa* are comparable with ranges reported earlier by Beniwal [16].

CONCLUSION

The batter volume increased for all the samples during fermentation over a period of 8 hours. Maximum rise in batter volume was found in HPR 814 (4.93 ml) and HPR 565 (3.03 ml) followed by HPR 930 (1.83 ml). Check variety (HP 9) showed 4.0 ml rise in volume. HPR 565 and HPR 814 and check variety were found to be better for fermented product preparations such as idli, dosa and ediappam etc. Development and consumption of Food products using such varieties can go a long way in improving the nutritional status of the population especially for those suffering from Protein Energy Malnutrition.

REFERENCES

1. Rice market monitoring. FAO. 2015; Volume XVII: Issue No 2.
2. Annual Report 2016-2017. Department of Agriculture, Cooperation &Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt. of India. Anonymous. 2017.
3. Dipti S, Bergman C, Indrasari SD, Herath T, Hall R, Lee H, et al. The potential of rice to offer solutions for malnutrition and chronic diseases. Rice (N Y). 2012; 5: 1939-8433.
4. Kiing S, Rajan PY, Wong S. Effect of germination on oryzanol content of selected Sarawak rice cultivars. Am J Appl Sci. 2009; 6: 1658-1661.
5. Bouman. Water-wise rice production. Los Baños (Philippines): Int Rice Res. Institute. 2002; 356.
6. Li J, Xiao J, Grandillo S, Jiang L, Wan Y, Deng Q, et al. QTL detection for rice grain quality traits using an interspecific backcross population derived from cultivated Asian (O. sativa L.) and African (O. glaberrima S.) rice. Genome. 2004; 47: 697-704.
7. Hegested DM. Nutritional value of cereal proteins in relation to human needs. 1969; 44: 38-48.
8. Coda R, Rizzello CG, Trani A, Gobbetti M. Manufacture and characterization of functional emmer beverages fermented by selected lactic acid bacteria. Food Microbiol. 2011; 28: 526–536.
9. Kannan D, Chelliah R, Vinolya Rajamanickam E, Srinivasan Venkatraman R, Antony U. Fermented batter characteristics in relation with the sensory properties of Idli. J. of Food Technol. Biotechnol and Nutr. 2015; 10: 37-43.

10. Kanchana S, Bharathi SL, Ilamaran M, Singaravadivel K. Physical quality of selected rice varieties. World J Agric Sci. 2012; 8: 468-472.

11. Srivastava RP, Kumar S. Important methods for analysis of fruits/ vegetable and their products. Fruit Veg Pres Prin Prac. 1993; 2: 321-229.

12. Sura K, Sarg S, Garg FC. Microbiological and biochemical changes during fermentation of kanji. J Food Sci Technol. 2001; 38: 165-167.

13. Ghosh D, Chattopadhyay P. Preparation of idli batter, its properties and nutritional improvement during fermentation. J Food Sci Technol. 2011; 48: 610-615.

14. Mukherjee SK, Albury MN, Pederson CS, Van AG, Steinkraus KH. Role of Leuconostoc mesenteroides in leavening the batter of idli, a fermented food of India. Appl Environ Microbiol. 1965; 13: 227-231.

15. Soni SK, Sandhu DK. Indian fermented foods: Microbiological and biochemical aspects. Indian J Microbiol. 1990; 30: 135-157.

16. Beniwal P. Nutritive evaluation and Glycaemic response of value added products developed from by-products of milled Bengal gram. Ph.D Thesis. CCS Haryana Agricultural University, Hisar, Haryana, India. 2013.

17. Deshmukh GP, Pawar PP. Optimization of formulation and development of carrot fortified Idli and its physic-chemical characterization. International Journal of Engineering Science and Research Technology. 2016; 5: 783-786.