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Resistant starch V incorporated idli batter and its Physico-chemical properties

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ABSTRACT

Idli is traditional fermented rice and black gram based food. Idli batter was prepared by soaking of parboiled rice and decorticated black gram for 6 to 8 h at 30±10° C in water. The present study is focused on improve the nutritional quality and acceleration of fermentation process in idli batter by incorporation of pearl millet resistant starch (PMRS V). Pearl millet resistant starch (5% and 10%) was incorporated into idli batter and its quality was evaluated. Control and resistant starch incorporated idli batter were fermented at room temperature, physico- chemical and microbiological properties were analyzed. Nutrients, texture and sensory evaluation were carried out for control idli as well as RS V incorporated idli. The pH and total titratable acidity of control batter at 12 h was 5.42 and 0.40% respectively; however RS 5% and 10% incorporated batter were found to be 5.49, 0.0.45 % and 5.31, 0.50 % respectively. Lactic Acid Bacteria (LAB) count was increased in RS (Resistant starch) incorporated batter. RS incorporated idli had higher protein and fiber content compared to control idli. Incorporation of RS at 5% and 10% in idli batter improved the texture and appearance of the idli and it also had better nutritional quality compared to control idli.

Key words: *Resistant starch V; idli batter formentation; nutrient analysis; sensory evaluation.*

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INTRODUCTION

Idli is a traditional cereal-legume based fermented steamed product, consumed as a breakfast food in many parts of India [1].It is traditionally prepared by soaking parboiled rice (*Oryza sativa*) and dehulled black gram dal (*Phaseolus mungo*), usually taken in 3:1 (w/w) proportion followed by grinding. Salt (0.9%) is added and the mixture is allowed to ferment overnight at room temperature [2].Replacement of rice in idli batter with other cereals will encourage the consumption of these underutilized cereals which are consumed in considerably lower amounts thanrice. Use of finger millet (Eleucinecoracana) improves the mineral content [3]. Sorghum (Sorghum bicolor) occupies an important place in Asian diet as it is a source of proteins, minerals, carbohydrates and also enhances dietary fibre content [4]. Pearl millet (*Pennisetum glaucum*) serves as an integral source of energy for the poor sections in the region of its cultivation [5]. Several authors have made attempts to replace rice in idli batter partially or completely with other cereals such as mixed millet [6],kodo millet [7], sorghum [4] and pearl millet [5]. Amylose is known to form single helical complexes with many other substances, including iodine, monoglycerides, lysophospholipids, fatty acids and alcohols. Amylose-lipid complex is commonly found in native starch granules and processed starch [8]. Amylose-lipid complex has been shown to reduce postprandial glycemic and insulinemic responses [9]. Cereal-based foods are a major source of energy in the daily diet of people worldwide due to the presence of starch as the main carbohydrate component. The rate and extent of starch digestion are nutritionally significant, particularly in populations with high prevalence of lifestyle diseases like diabetes. The RDS fraction is responsible for a sudden sugar in levels of blood glucose, SDS fraction undergoes slower digestion in the small intestine, while RS escapes digestion and is eventually fermented in the large intestine [10]. The biochemical's changes occur during natural fermentation include increase in non-protein nitrogen, total acids, soluble solids, methionine, cystine and a decrease in reducing sugars, pH and soluble nitrogen [11, 12]. During fermentation of idli batter overnight, the naturally occurring microorganisms viz. *Leuconostocmes enteroides* and *Streptoccous thermophilus* in grains/legumes/utensils grow rapidly, outnumbering the initial contaminants and dominating the fermentation. These microorganisms produce lactic acid (≥1.0%) and carbon dioxide that make the batter anaerobic and leaven the product. Several aspects such as effect of raw materials, effect

of fermentation or processing temperature and microorganisms involved in biochemical and nutritive changes have been investigated. 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 [13]. Production of *idli* batter is a time consuming process sometimes requiring 24 h to get the desired quality of *idli* and hence hastening of fermentation process is an important parameter. Therefore the objective of the present study resistant starch (RS V) incorporated Idli batter fermentation and its characteristics.

MATERIAL AND METHODS

Procurement of raw materials

Pearl Millet grains (CO 10), rice (T4M 13) and black gram dhal (VRB 8) were procured from Tamil Nadu Agricultural University, Coimbatore. Chemicals like sodium chloride (NaCl) sodium hydroxide (NaOH) and phenolphthalein (Analytical Grade) were purchased from Nice chemicals Kochi, India. De Man Rogosa and Sharpe (MRS) Agar, Sarbouraud Dextrose Agar (SDA) was purchased from Sigma- Aldrich.

Isolation of Pearl millet starch

Isolation of pearl millet starch was determined by the method of Ali and Hasnain [14].

Preparation of 'idli' batter

Hand pounded rice and split black gram dhal, in ratio of 3:1 (the ratio was selected based on prior of standardization studies), were soaked separately for six to eight hours. Idlibatter was prepared by grinding wet rice to a coarse consistency and black gram to a smooth consistency, separately in a kitchen blender. Both were then mixed together with common salt (2 % w/w). The batter was then transferred to a stainless steel vessel, covered with a lid and fermented ambient temperature for 12 h [15].Idli batter incorporated with resistant starch V (RS V) 5 % and 10 % . The fermentation was carried out for 14 h in both idli batters. The samples of fermented batter were drawn at every 2 h interval and subjected to physico-chemical analysis.

Bulk density

Bulk density was calculated as the ratio of mass to volume of the idli batter. The prepared batter sample was placed in 500 ml measuring cylinders up to the mark of 100 ml, covered with the aluminium foil and kept at 30°C to observe the rise in the volume during fermentation [16]. Initial and final readings for the leavening action of batter were noted.

Viscosity

Flow behavior index was determined using a viscometer (Brookfield, DV-E).

Microbiological analysis

The viable count of Lactic acid bacteria (LAB), mesophilic bacteria and yeast of the naturally fermented 'idli' batter (control and RS) was estimated by the following methods. 10 g of sample was homogenized with 90 ml of sterile diluents (0.85 % NaCl) for 2 min in a shaker at normal speed. Ten fold serial dilutions were prepared and pour plated on MRS agar for the enumeration of LAB. Spread plate technique was employed to determine the counts of total mesophilic bacteria and yeast and molds using Nutrient agar (NA) and Potato dextrose agar (PDA) respectively [17].

Preparation of idli

The 12 h fermented idli batter of both control and RS incorporated idli batter were cooked by steaming for 15 min in idlimoulds and the idlis were studied for the following characteristics.

Texture analysis of idli

Texture profile analysis of idli was performed using a texture analyzer Modal TA-XT2i, Stable Micro systems Ltd. With a measured force in compression test selected. The instrument was connected to the texture expert computer program to analyze the data. RS incorporated 5 % and 10 % were measured. The parameters determined were hardness, stickiness, springiness, cohesiveness, stringiness, chewiness, Adhesiveness and gumminess of the idli were measured using a TA XT2 Texture Analyzer (Stable Micro system, USA) equipped with the AACC 26 mm cylindrical probe (P/26R). Firmness is defined as the force (in grams, kilograms or Newtons) required for penetrating the product.

Nutrient analyses of the Idli

Moisture content of idli was estimated by the method of Adebayo et al.,[18], Crude protein content of the idli samples was determined using the Kjeldahl method (AOAC,2000, 979.09) [19]. Fat content of idli sample was determined by automated Soxhlet apparatus using the AOAC (2000, 4.5.01) protocol [20].Crude Fibre content of the idli sample was determined using AOAC (2000,920.169) protocol. Dietary fiber analysis was determined by method 991.43 of AOAC (2000) [20].

Total carbohydrate

Total carbohydrate content was calculated by difference method (Southgate, 1991) as follows:

% Total carbohydrate = 100 % - (% moisture + % ash + % crude protein + % crude fat). [21].

Apparent amylose and total starch

Apparent amylose and total starch were estimated by the method of Williams et al.,[22] (1970).

Determination of Organoleptic properties

Quality is the ultimate criterion for the desirability of any food product. Organoleptic properties of idli were evaluated by a panel of 25 semi-trained members. A nine point score card was developed on the basis of numerical rating scale and the samples were tested for their organoleptic properties namely appearance, colour, texture, flavor and taste.

Statistical analysis

All the experiments were conducted in triplicate and statistical analysis was performed using SPSS version 18.0 software. One way analysis of variance (ANOVA) was used to determined the significant differences between means, with the significance level at ($P<0.05$).

RESULTS AND DISCUSSION

Physicochemical analysis of idli batter

Idli batter variants of control, RS V 5 % and 10 % incorporated batter were subjected to studies on physicochemical properties such aspH,titratable acidity and batter volume of control and RS V incorporated idli batter are representation in Fig .1 (a) and (b). The pH value of control idli batter was decreased(5.7 to 5.31) as the fermentation time increased from 0-14 h. This result was similar with Ghosh and Chattopadhyay [23]. Similarly significant reduction of pH was also observed in RS incorporated idli batter at 5 (5.80 to 4.66) and 10% (5.61 to 4.60). An increasing trend of acidity level was related with decrease in pH. This is mainly associated with the development of *S.faecalis*producing lactic acid, which lowers the pH value [24].Total acidity of control idli batter at different fermentation time was in the range of 0.2 to 0.5 % and it also increased at 5 (0.19 to 0.53) and 10 % (0.15 to 0.54) incorporation of RS. Rekha and Vijayalakshmi (2011) reported that in okara fortified batter, acidity was higher (0.18 to 0.64) than in unfortified batter (0.15–0.43). The increase in acidity may be due to the high amount of soluble protein, amino acid and free fatty acid present in okra fortified batter [25]. pH and titratable acidity of Idli batter from polished parboiled rice and decorticated black gram blend in a ratio of 2:1, 3:1 and 4:1 (v/v) were in the range of 5.9–4.1and 0.443–0.910 %, respectively [24].

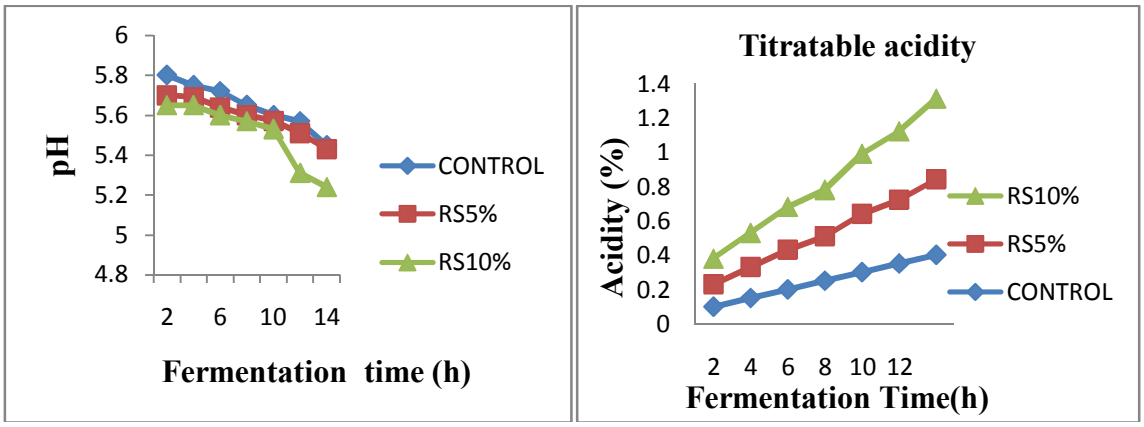

Fig.1(a):pH Values of control and RS incorporated idli batter Fig.1(b):Titratable acidity of control and RS incorporated idli batter

Bulk density

The volume of control batter was increased two-fold after 12 h fermentation time while RS incorporated batter volume was increased at 8 h. This might be due to the CO2 production by the yeast during natural fermentation and it is a measure of metabolic activity. This is also because of combined contribution of both hetero fermentative lactobacilli and non LAB [26]. Since both leavening and acid development are required for 'idli', determination of the end point of the 'idli' fermentation becomes rather arbitrary. However, the use of different ingredients in different proportions resulted in raise in volume besides reduction of fermentation period [27].

Viscosity of idli batter

Idli batter viscosity measured in centipoises (cps) is an important parameter determining the end product quality. The effectiveness of pearl millet resistant starch in reducing the viscosity of idli batter. The viscosity of control idli batter was found to be 7,912 cps, 5% and 10 % RS viscosity values of 9,405 cps, 9,507 cps.

Microbiological analysis

The microbial population of LAB in idli batter fermentation with a steady increase of LAB counts from 6 to 12 h for the control batter, which was reduced to 4 and 6 h for RS 5% and 10% batters, respectively. RS incorporated idli batters showed higher microbial counts compared to the control. Okra fortified idli batter there was a gradual increase in mesophilic bacterial and LAB count with fermentation time as well as yeast and mould count. Thus the bacterial counts were higher in okra fortified batter than control batter. It has been previously reported that ingredients in foods such as black gram affect the microbial population as they provide a source of nutrients for the growth of microorganisms during fermentation [23]. Yeasts contributed to the leavening of the batter with a steady increase throughout the 16 h fermentation in all batters and a rapid increase in the RS incorporated batter. The steady increase of yeast at later stages of fermentation was slower. This in turn affects the CO2 production in idli batter resulting in the higher bulk density in the RS batter than the control batter. Addition of RS5% and 10% to the unfermented batter resulted in rapid growth of bacteria and yeast and thereby reducing the fermentation time from 12 to 6 h leading to accelerated fermentation. Iyer and Ananthanarayan reported reduction (14–8 h) in fermentation time of idli batter by addition of an exogenous source of a-amylase enzyme [28]. Rekha and Vijayalakshmi reported higher bacterial counts along with gradual increase in yeast and mould counts in okra fortified idli batter [13]. Ghosh and Chattopadhyay suggested that black gram, as a source of protein in foods enhances the microbial population [23].

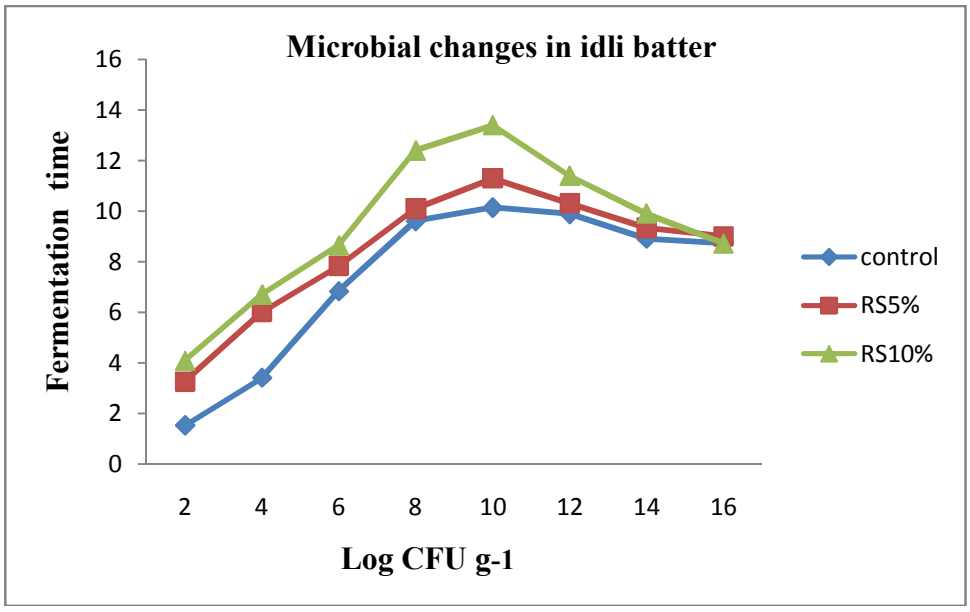

Fig 2. Microbial changes in control and RS incorporated Idli batter

Nutritional analysis

The proximate composition of 100 g Control and PMRS incorporated idli given in the Table 1.

Parameters (%)	Control idli	RS 5% idli	RS 10% idli
Protein	11.56±0.82	12.01±0.20	13.50±0.02
Fat	0.11 ±0.09	0.02 ±0.01	0.02±0.01
Fiber	0.28 ± 0.05	0.42±0.03	0.66±0.02
Total starch	51.1 ±0.71	41. 95±1.21	40.9±1.04
Apparent Amylose	31.0 ±0.57	21.6 ± 0.70	25.2± 0.03
Moisture	65.96 ± 4.37	66.79 ±0.05	67.39 ± 0.05
Total CHO	22.09 ±0.33	20.76±0.50	18.43 ±0.06

All values are means of triplicate determination standard deviation (SD).

The RS incorporated idli had 13.5 % higher protein content compared to control idli. The fiber content of control idli was 0.28% and 5% and 10% RS idli were 0.42 and 0.66% . Higher moisture content was observed in RS incorporated idli and low carbohydrate content was observed.

Texture analysis of 'idli'

Textural parameters of idli prepared using control and RS fortified batter. Idli has a circular shape of approximately 7–10 cm diameter (depending on the mould size) flat with lower and upper surface

bulging, so that the product is thick at the center (2–4 cm) and tapering towards periphery [29].The RS incorporated idli were softer and easy to bite compared to control idli (soft texture of 'idli's is a desirable quality). This is due to the microbes present in RS especially yeasts, which produced CO_2 during natural fermentation resulting in a softer product and partial substitution of black gram with RS might be contributed for accelerated natural fermentation.

Table .2 Texture analysis of RS V incorporated idli

Parameters (N)	Control Idli	RS V 5% idli	RS V 10%
Hardness	8.64 ± 0.80	4.282±0.21	3.29±0.13
Stickiness	-0.12±0.02	-0.12±0.10	-0.30±0.15
Springiness	0.925±0.02	0.941±0.05	0.95±0.05
Cohesiveness	0.455±0.07	0.475±0.20	0.49±0.04
Stringiness	0.520±0.31	0.147±0.05	0.62±0.89
Chewiness	3.647±0.43	1.915±0.16	1.55±0.15
Adhesiveness	0.003±0.05	0.003±0.01	0.110±0.19
Gumminess	3.935±0.40	2.033±0.10	1.62±0.07

N- Newtons, RS –Resistant Starch, % - percentage
Values reported as Mean± S.D of triplicates

Sensory evolution

The scores of sensory evaluation of control and RS fortified 'idli' batter are presented in Table 3.

Table .3 Organoleptic Properties of control and RS V incorporated idli

Parameters	Control Idli	RS V 5% idli	RS V 10% idli
Appearance	7.26 ± 0.15^{a}	7.24 ± 0.14^{b}	7.13 ± 0.08^{c}
Texture	7.54 ± 0.14^{a}	7.10 ± 0.05^{b}	7.10 ± 0.30^{c}
Flavor	6.80 ± 0.18^{a}	6.80 ± 0.25^{a}	6.26 ± 0.21^{b}
Taste	6.95 ± 0.83^{a}	6.35 ± 0.94^{b}	6.30 ± 0.81^{c}
Colour	7.20 ± 0.58^{a}	7.30 ± 0.59^{b}	7.50 ± 0.67^{c}

Mean ± SD of 9-point Hedonic scale.

The effect of incorporating RS 5 % and 10% levels on sensory attributes of idli like appearance, texture, flavor, taste and color were studied. Control idli has got a highest scores of 7.26 followed by 5% incorporated idli with a score of 7.24 and the least score 7.13 is obtained by the 10% incorporated idli for the appearance attributes. Regarding the texture attributes the highest score 7.54 is obtained by control idli followed by the same score was obtained 5% and 10% incorporated idli. Darken color was observed in 10% incorporated idli compared to control and 5% incorporated idli. Overall acceptability scores of control idli, 5% and 10% idli were found to be 8.27, 7.86 and 7.28 respectively. Both 5% and 10% level of incorporation accepted equal to control idli.

CONCLUSION

The best quality of idli in terms appearance, color, texture, flavor and taste were achieved with control and RS incorporated idlies. The batter prepared by using 5% and 10% RS showed reducing in fermentation time 6 h. Pearl millet resistant starch using acceleration of fermentation of idli batter. RS not only reducing the fermentation time it increased the nutrient content of the idli particularly protein and fibre. Resistant starch is one the fibre so fibre rich in food product reducing GI and prevent diabetes mellitus, heart disease and obesity. Reduction in the fermentation time of the idli batter is of great commercial significance for large-scale idli production.

CONFLICT OF THE INTEREST

The authors declared no conflict of interest

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