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Effect of stirring on the rheological, textural and structural characteristics of Idli batter and steamed Idli

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Abstract
The predominant feature of idli is its lightness due to soft texture. Various factors affecting the texture of idlis has been discussed but the effect of trivial factors like stirring are not explored or reported. The key objective of this study is to examine the effect of stirring on the characteristics of idli batter and idli. The effect of stirring to examine the influence of air content present in batter was evaluated. The unstirred batter required lower cooking time and temperature and the idlis made out had softer texture when compared to control idlis. The structure of idli made with unstirred batter had a good number of air vacuoles. The studies concluded that there was a significant difference in the quality of idlis due to stirring of batter. The presence of voids maybe the primary reason. The data obtained were analysed with two-way ANOVA and the conclusions were made.

Keywords: stirring, pasting profile, texture, acceptability

1. Introduction
Idli is a soft fermented spongy cake mostly taken for breakfast in South Asian countries. It is also taken as a snack in various parts of the world. Being a food of Indian origin, idli has now gained the attention and importance from people all over the world due to its inherent quality. The predominant feature of idli is lightness due to its soft texture. Idli is made by steaming the fermented batter which is prepared using parboiled rice and dehusked whole black gram that makes idli a complete nutritious meal, with significant amounts of proteins, carbohydrates and absolutely less fat or zero cholesterol. The rice and pulse are soaked for 5-6 hrs and ground separately. The resulting batters are mixed with addition of salt and allowed for natural fermentation, which is due to the inherent microorganisms in the food grains. Fermentation also makes idli a functional food, with a good probiotic profile and enriched B & C vitamins and amino acids. The anti-nutritional factors are reduced as well (Shrivastava & Ananthanarayan, 2014) [8]. Fermentation causes two significant effects in the batter: leavening and acidification, which rises the volume of batter due to the developed gas and acidity. The lactic acid bacteria *Leuconostoc mesenteroides* and *Lactobacillus fermentum* were mainly responsible for leavening and the level of leavening is proportional to the microbial population present in the batter (Padhye, 1978) [7]. An increase in volume with low bulk density denotes good quality batter (Kavitha *et al*., 2016) and a good volume batter yields good quality light idlis. A positive correlation was found between fermentation (LAB count) and texture and further, texture and overall acceptability, upholding the pivotal role of fermentation in the quality of idli (Kannan *et al*., 2015) [5].
Texture, being a predominant character for the desirable quality of idlis, is affected by a number of factors and hence preparing idlis with right texture becomes a tougher task. Various factors affecting the texture of idlis has been discussed in the studies done by Balasubramanian & Viswanathan (2007) [2], Durgadevi & Shetty (2012) [4] and Kannan *et al*. (2015) [5]. However, the effect of trivial factors such as stirring have not been explored and reported in the scientific domain, yet. Therefore, the main objective of this study is to examine the effect of stirring on the primary characteristics like colour, texture, rheology and structure of idli batter and idli.

2. Materials and Methods
2.1. Preparation of idli batter
Parboiled rice and dehusked black gram were purchased from the local market of Thanjavur. Rice and black gram in the ratio of 4:1 was taken for the entire study. Both soaked rice and black gram have been ground in wet grinding method using 85 watts wet grinder (Micro: 1.75L,

Elgi Ultra Ltd, India). A grinding time of 30 mins was given for black gram while 20 mins was given for rice. Then the batter of rice and black gram has been mixed thoroughly for 2 min using stainless steel ladle. 1% of cooking rock salt was added while mixing. Then, the mixed batter was allowed for natural fermentation for 9 hrs under ambient conditions.

As conventional practice, the fermented batter is stirred manually before pouring the batter in the idli mould. However, in this study, in order to examine the effect of stirring, after fermentation, the leavened batter was taken for idli making without stirring. The conventional practice has been taken as control. The prepared batter was finally poured in the idli pans and cooked using idli steamer, made up of aluminium with 2 trays was used. Steaming time was fixed as 10 mins. After steaming, the idlis were allowed to cool to room temperature for 30 min.

2.2. Rheology of idli batter

The pasting properties of the batter was measured using the starch cell of Rheometer (MCR-52 series, Anton Paar, UK). The rheological parameters like peak viscosity, pasting temperature and time, holding strength, breakdown, final viscosity, setback from peak and trough were measured using time-temperature-viscosity curve.

2.3. Texture of idli

The texture of idlis was measured by TPA test using Texture Analyser (Model TA.XTplus, Stable Micro Systems, UK). The whole idli was taken as sample for TPA test. The test was carried out with a 35 mm compression probe supported by a 30kg load cell. The distance of compression of idli was 10mm while the test speed was 1 mm/sec. The parameters measured include hardness, resilience, cohesiveness, adhesiveness, springiness, gumminess, chewiness and firmness.

2.4. Color of idli

The color attributes such as Lightness (L* value – white to grey scale), absorbance (a* value – green to red) and brightness (b* value – blue to yellow) of the idlis were measured by Hunter Lab Colorimeter (ColorFlex EZ, Hunter Associates Laboratory Inc., US). The idlis were cut in to small pieces, filled in the sample cup and then the L*, a* & b* values were observed.

2.5. Structure of idli batter and idli

The structure of the idli batter and idli was observed under Scanning Electron Microscope (SEM) (EVO-18, Carl Zeiss, Germany). A very small amount of sample was taken and directly mounted on aluminium stubs after which it was subjected to the vacuum chamber. The structure of the samples was observed under 3000X magnification.

2.6. Statistical Analysis

The statistical analysis of data was performed by IBM SPSS software (Version 25). The data were analysed using LSD and Tukey two-way ANOVA test at 5% level of significance.

3. Results and Discussion

3.1 Effect of stirring on the rheology of Idli batter

Fermentation of idli batter results in leavening, due to the gas formation, which is a result of the native microbial activity it had undergone (Padhye, 1978) [7]. The unstirred batter and the control batter were tested for its pasting properties and the results are tabulated in Table 1 (the batter without the expulsion of gas is termed here as unstirred batter and after expulsion is termed as control batter). The peak viscosity were high for control batter. This is because the dissolved air exerts higher pressure which reduces the viscosity of unstirred batter (Beecher & Parkhurst, 1926) [3]. Hence, higher the air content, lower is the viscosity. The pasting time and temperature were less for unstirred batter than the control batter indicating that it requires comparatively lesser time for cooking due to the voids present in it enabling quicker convective heat transfer. The hot paste viscosity was high for unstirred batter showing that it has lower susceptibility to fragmentation and higher shear resistance. Higher the breakdown viscosity, higher is the batter stability. The control batter had better stability when compared with the unstirred batter. The higher final viscosity or the end viscosity of control batter shows its higher ability for retrogradation of molecules when compared to the unstirred batter since the air present inside the unstirred batter may act as a hindrance while retrograding.

Table 1: Pasting properties of unstirred and control batter

Sample	Peak Viscosity mPa·s	Pasting Time min	Pasting Temp ºC	Trough Viscosity mPa.s	Breakdown Viscosity mPa·s	Final Viscosity mPa·s
Unstirred	10060	0.8075	49.98	789.7	9272	1210
Control	13250	3.089	62.25	491.5	12760	1599

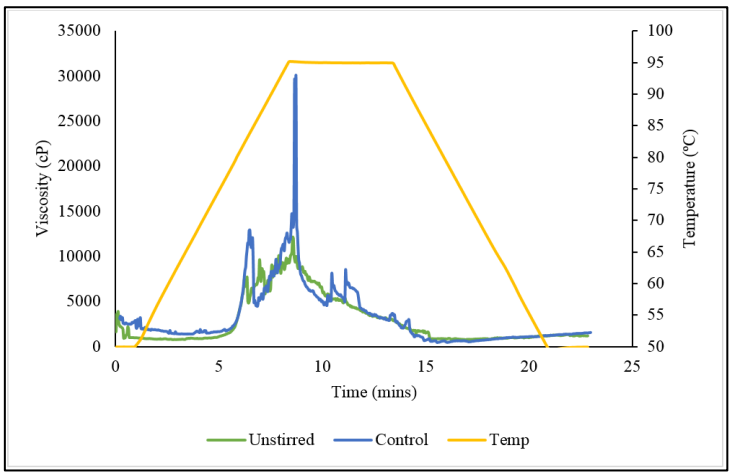

Fig 1: Pasting profile of Unstirred and Control idli batter

3.2 Effect of stirring on structure of idli batter and idli

The SEM images of unstirred and control idli batter under 3000X magnification is shown in Fig. 2a and 2b. From the images, it is obvious that the unstirred idli batter has more air pockets than control idli batter. It is also clear that the batter with more air pockets had discrete particles while the one after expulsion of air showed aggregate particles in the batter. This could pose a possible and significant change in the texture of idli. A similar structural difference was observed in the idlis made from respective batters. The structure of idli made with unstirred batter also had a good number of air vacuoles.

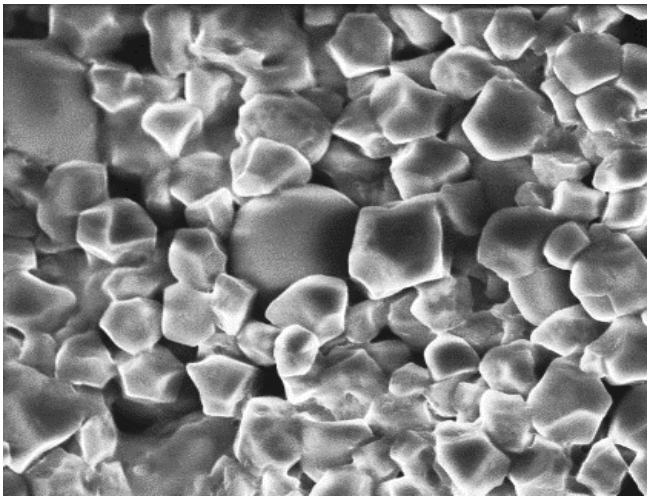

Fig 2a: Unstirred batter

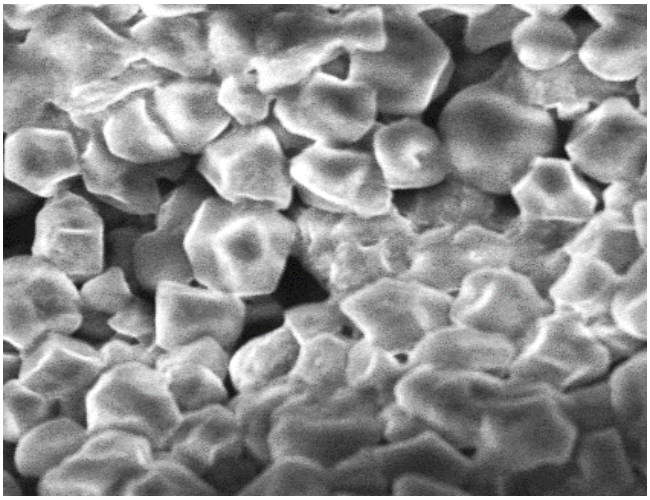

Fig 2b: Control batter

3.3 Effect of stirring on the texture of Idli

The unstirred batter and control batter were used for making idlis. When the batter was used as such for idli preparation without the expulsion of gas, the idlis came out with very soft texture. When the batter was used after expulsion of gas, the idlis relatively had hardness higher than the former. This variation of texture is just because that the batter, though it was mixed thoroughly before fermentation, had black gram batter on its top after fermentation since it has a low density of 903–818 kg/m^3 (Swami *et al*., 2004) [9] when compared to the rice batter. The results of TPA test was compared in Fig 3. The hardness, firmness and chewiness had a positive correlation between them and was higher for control idli than the unstirred idli. This is in par with the correlation obtained by Balasubramanian & Viswanathan (2007) [2]. The voids present in the unstirred idli batter gave good porosity to idlis resulting in lower hardness, firmness and chewiness. There was no significant difference in the cohesiveness of idlis. The gumminess value was also higher for unstirred idli since it is a function of hardness and cohesiveness. Higher springiness was observed in unstirred idlis due to the possession of air pockets in it. Studies revealed that the quantity of black gram in the batter had a significant effect on the springiness of idli due to the presence of arabinogalactan which has the potential to entrap the air bubbles and form network between the rice and black gram molecules (Durgadevi & Shetty, 2012) [4]. The resilience value was higher for unstirred idlis than control idlis. The higher resilience shows its ability to recover from compression at a faster pace due to the presence of higher air content as available on cakes (Agrahar-Murugkar *et al*., 2016) [1]. The adhesiveness values were negative in both the cases adhering to the non-sticky nature of idlis. On the whole, unstirred idlis had lower hardness, adhesiveness, chewiness and firmness with higher springiness which are the most important attributes for the desirable quality of idlis.

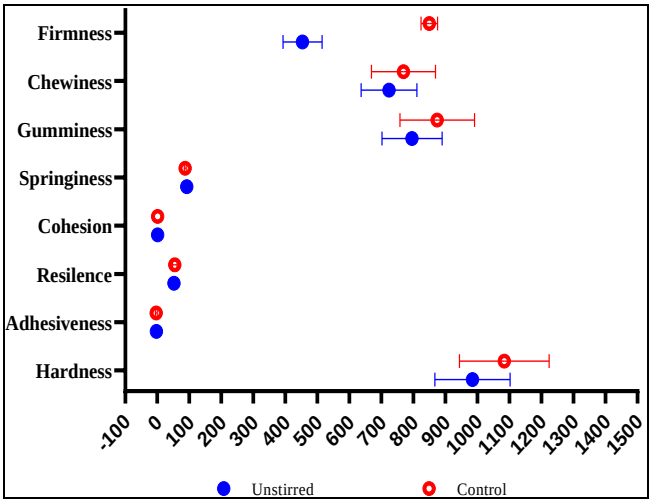

Fig 3: Texture Profile of Unstirred and Control Idli

3.4 Effect of stirring on the color of Idli

The color values L*, a* and b* was lower in unstirred idlis when compared with control idlis (Table 2). This may be due to the presence of voids inside the idli which deflected the light rays in unstirred idlis while the uniform or even internal structure of control idlis gave high and true values. There was significant difference in the lightness of idlis while the absorbance and brightness values remained insignificant. Though there is significant difference in L* value, the value is >75 in both the cases making both acceptable. Therefore, the presence of higher air content in the batter has a marked effect on the acceptance of idlis. This could be a positive arena to improve the texture of idlis just by incorporating air into it. A similar kind of study was done in black gram batter (Swami *et al*., 2004) [9].

Table 2: Color variation due to stirring

Parameter		Treatments	
		Unstirred	Control
Color	L	77.64±0.34^a	79.05±0.49^b
	a	-0.6033±0.045^a	-0.5167±0.038^a
	b	12.08±0.22^a	12.36±0.21^a

4. Conclusion
Unstirred idlis had softer texture when compared to control idlis. The rheological, textural and structural studies concluded that there was a significant difference in the quality of idlis due to stirring of batter. The presence of voids in it may be the primary reason for the resulting change. This study ends up with the idea of incorporation of air content into batter for acquiring the desirable textural quality. There are yet more number of factors that are neglected during idli batter and idli processing. On accounting those factors into picture and controlling them, it would be possible to have good quality idlis from batter procured from the industries.

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6. Conflict of interest
The authors declare no conflict of interest.

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