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# Comparison study among textural, color, and sensory characteristics of Idli

**Ashwathi KC, V Eyarkai Nambi, V Chandrasekar and R Jagan Mohan**

**Abstract**
Idli is preferred as a breakfast food by millions of consumers because of its appealing nature, spongy and soft texture, pleasant aroma, and fermented sour taste. This study aims at comparing the textural, color, and sensory characteristics of idli. Idlis were made using various ratios of rice and black gram at various fermentation durations, with hotel samples used as a control. All the idlis were analysed for textural, color, and sensory parameters along with ink test method. Pearson correlation was performed among the obtained results. In which the correlation among different parameters in the textural analysis showed that most of the textural parameters are positively correlated at $p<0.05$. The highest correlation was shown by gumminess with hardness and chewiness at a correlation coefficient of $r=0.87$ and $r=0.99$. Correlation performed for sensory assessment showed that overall acceptability is significantly correlated ($p<0.05$) to other sensory properties in the order, flavor ($r=0.91$) > taste ($r=0.88$) > softness ($r=0.78$) > color ($r=0.63$) > appearance (-0.51). Wherein the Pearson correlation test for color parameters showed a negative correlation between L* value and b* value ($r=-0.57$, $p<0.05$). The number of pores obtained from the ink test had a significant correlation with many sensory properties. According to the PCA results for the textural parameter, the first principal component has strong positive correlations with cohesiveness, chewiness, and gumminess, whereas the second principal component has positive correlations with hardness and negative correlations with springiness. PCA for sensory attributes shows that the majority of the sensory properties fall on the positive side of the first principal component.

**Keywords:** Idli, textural property, sensory attributes, color, pearson correlation

## 1. Introduction
Idli made up of rice and black gram is consumed as a breakfast food in many parts of India ans well as Sri Lanka. Idli is prepared by fermenting batter made of rice and black gram. For this, rice and black gram are soaked and pounded using a mortar and pestle with water. After adding salt it is allowed for fermentation (Balasubramanian & Viswanathan, 2006) [6]. Idli are then made by steam cooking the fermented batter. It is a common, well-liked, wholesome, and light food that is primarily eaten for breakfast. Idli is renowned for its soft and spongy texture, which facilitates simple digestion.
The sensory qualities and texture characteristics of idli make it immensely popular. The major method of evaluating idli quality is sensory assessment and texture profile analysis. The primary causes of diversity in the sensory characteristics of idli are the quality and variety of the raw materials used, their proportion, the soaking period, the grinding environment, and the fermentation period. According to reports, black gram serves as a substrate for fermentation as well as a source of bacteria essential for idli fermentation.
Idlis are eaten widely around the world, including in the army, on trains, at workplace canteens, etc. Even though idli is a traditional food, it has been an important part of the area of research for decades. Numerous studies reported idli's textural and sensory qualities based on rice to black gram proportion and fermentation time (Susmitha *et al*., 2022; Agrawal *et al*., 2001; Durgadevi & Shetty, 2014; Kannan *et al*., 2015) [11, 6, 8, 1] The texture and sensory of idli helps to optimize the ingredients and cooking time for the production of idli according to consumers preference. Consumers prefer soft, spongy idli having bright/white color with a mild sour taste (Durgadevi and Shetty, 2012b) [6]. The purpose of the study is to establish a correlation between idli's sensory features, textural attributes, and colour properties.

## 2. Materials and Methods
### 2.1 Idli preparation
The ingredients used in idli preparation included rice variety CR-1009, dehusked black gram,

and salt. All the ingredients were stored in airtight containers under ambient conditions. The raw materials taken in definite proportions were washed 3-4 times beforing soaking for 4 hours. After soaking, the traditional wet grinding method was followed using a motorized, stone wet-grinder. The wet grinding time has been fixed as 20 minutes for rice and 15 minutes for black gram. The grounded ingredients were mixed thoroughly with 2% w/w of salt. And allowed for fermentation from 12 to 24 hours. The fermented batter was then poured onto an idli moulder and steamed for 15 minutes. The idli was sent for further analysis after reaching room temperature. 28 batches of samples were prepared, and commercial samples were collected from hotels as control samples, each batch containing 10 samples.

### 2.2 Sensorial property analysis

A semi-trained sensory panel of 10 members (aged between 18 and 25 years) with sound good health was set up. Sensory evaluation of idlis was done with the most commonly used difference rating test, the nine-point hedonic scale and scored from one to nine as given below:

| | | |
|---|---|---|
| Like extremely | Like very much | Like moderately |
| Like slightly | Neither acceptable nor unacceptable | Dislike slightly |
| Dislike moderately | Dislike very much | Dislike extremely |

The attributes covered include appearance, color, flavor, softness, fluffiness, stickiness, taste, and overall acceptability. The test was conducted in a peaceful environment between 10 am to 12 pm, with a batch of 5 panel members at a time in individual booths and the results were recorded in excel. The panelists evaluated the idli samples by comparing it with the control idlis. The sensory evaluation was carried out on idli samples arranged in three groups, with one idli each. All idlis are of various quality.

### 2.3 Textural and Color characteristics analysis

Textural characteristics of idli was measured using texture profile analysis (TPA) method. Idli sample was taken as a whole and analysis was performed on Texture Analyzer. The probes used for analysis is cylindrical (P/35) in shape. Hardness, springiness, adhesiveness, gumminess, cohesiveness, chewiness, and resilience were the parameters measured in TPA (Chelliah *et al*., 2016) [4].

Hunter Lab Colorimeter was used for measuring the color attributes such as L*, a*, and b*. L* measures lightness, -a* to a* measures the value from green to red, and -b* to b* measures the value from blue to yellow. Each idli was sliced into a small piece and placed in a sample cup to quantify Color.

### 2.4 Ink print test for internal structure analysis

Internal structure of the idli can be assessed by the pores present in it. This can be achieved by ink printing the cross-sectional of an idli. For this an idli is cut into two even halves and dipped in ink and printed in a graph sheet (Nazni & Shalini, 2010) [10]. The area covered are manually counted.

### 2.5 Statistical analysis

For data analysis of the sensory attributes, color characteristics and textural properties of each sample, the mean score of each attribute was obtained. Pearson correlation coefficient between textural properties, color characteristics and sensory scores measured, were calculated for exploring the relationship between them using JMP (SAS Institute Inc.). Principal component analysis (PCA) was performed by Origin Pro 2022b (Learning edition).

## 3. Result and Discussion

Mean scores of the measured attributes were found out for further analysis. All of the measured textural, color and sensory characteristics were analysed for correlation at a significance difference of $p<0.05$.

### 3.1 Comparison among textural parameters of idli

Table 1 explains the correlation among the measured textural parameters. Hardness showed a positive correlation with gumminess and chewiness with a correlation coefficient of $r=0.89$ and $r=0.88$ respectively at $p<0.05$, whereas negative correlation with springiness at a correlation coefficient of -0.54. In order to confirm the findings, it is important to understand the terms hardness, gumminess, and chewiness. Chewiness refers to the time to chew a food item to a specific consistency in such a way that it can be swallowed, gumminess is the resistance a consumer feels when chewing, and hardness refers to the amount of force that is needed to crush a food between teeth (Lambert-Meretei *et al*., 2010). When compared to springiness, which gives ratio between second compression period and first compression period, hardness is the peak force of the product's initial compression, which clearly shows their antagonistic relationship. Gumminess is significantly correlated to chewiness with a high correlation coefficient of $r=0.99$ ($p<0.05$) and also with cohesiveness ($r=0.67$, $p<0.05$). The springiness had significant correlation to gumminess with a regression value of $r=-0.43$($p<0.05$). Cohesiveness is significantly correlated to springiness ($r=0.68$, $p<0.05$) and chewiness ($r=0.60$, $p<0.05$).

**The following relation supports the obtained results**

Gumminess= hardness*cohesiveness

Chewiness= gumminess*springiness

There is little correlation between resilience and the other parameters. Since the TPA resilience parameter was not sensitive enough to identify any differences between the treatments, its value in evaluating idli texture is questionable. Additionally, this parameter is not suitable for defining the textural characteristics of idli (Balasubramanian & Rangaraju, 2007) [7]. All of the obtained results substantiate that the textural property varies accordingly with change in ingredient proportion and fermentation time.

**Table 1:** Pearson correlation matrix among instrumental (TPA) measures (n=28, $p<0.05$)

| | Hardness | Adhesiveness | Springiness | Cohesiveness | Gumminess | Chewiness | Resilience |
|---|---|---|---|---|---|---|---|
| Hardness | 1.00 | | | | | | |
| Adhesiveness | 0.34 | 1.00 | | | | | |
| Springiness | -0.54 | 0.48 | 1.00 | | | | |
| Cohesiveness | -0.05 | 0.36 | 0.68 | 1.00 | | | |
| Gumminess | 0.89 | 0.39 | -0.43 | 0.67 | 1.00 | | |
| Chewiness | 0.88 | 0.41 | -0.29 | 0.60 | 0.99 | 1.00 | |
| Resilience | -0.05 | 0.32 | 0.41 | 0.25 | 0.26 | -0.30 | 1.00 |

### 3.2 Comparison among sensory parameters of idli

Due to the conventional product's widespread acceptability and appealing aroma, taste, and consistency, the desirable and undesirable idli criteria were assessed by sensory analysis of many cooked variations of idlis (Durgadevi & Shetty, 2012a) [5]. Table 2 shows the corelation matrix of the sensory parameters measured. Appearance being an important sensory property is significantly correlated to color ($r$=.073, $p<0.05$). Usually consumer prefers Idlis which are bright/ white in color. Softness and fluffiness shares a positive correlation with a regression value of $r$=0.70 ($p<0.05$). Flavour had positive correlation with taste ($r$=0.90, $p<0.05$). Taste gives the sourness of idli, whereas flavor shows the characteristics aroma obtained once the batter is fermentated. Both aroma and sourness are considered important for consumer acceptability. The overall acceptability is significantly correlated at $p<0.05$ to other sensory properties in the order flavor ($r$=0.91) > taste ($r$=0.88) > softness ($r$=0.78) > color ($r$=0.63) > appearance (-0.51).

**Table 2:** Pearson correlation matrix among sensory scores (n=28, $p<0.05$)

| | Appearance | Color | Flavor | Softness | Fluffiness | Stickiness | Taste | Overall acceptability |
|---|---|---|---|---|---|---|---|---|
| Appearance | 1.00 | | | | | | | |
| Color | 0.73 | 1.00 | | | | | | |
| Flavor | -0.09 | 0.27 | 1.00 | | | | | |
| Softness | -0.16 | 0.33 | 0.79 | 1.00 | | | | |
| Fluffiness | 0.31 | 0.27 | 0.33 | 0.70 | 1.00 | | | |
| Stickiness | 0.32 | -0.19 | -0.06 | -0.50 | 0.07 | 1.00 | | |
| Taste | 0.02 | 0.31 | 0.90 | 0.69 | 0.36 | 0.08 | 1.00 | |
| Overall acceptability | -0.51 | 0.63 | 0.91 | 0.78 | 0.35 | -0.03 | 0.88 | 1.00 |

### 3.3 Comparison among color parameters of idli

L* value that measures the lightness of the idli was correlated negatively with b* value ($r$=-0.57, $p<0.05$). Idli which has yellow tint are not bright/white. Due to variations in ingredient ratios and fermentation times, the color of the idli changed. With longer fermentation times, idli's colour got better. The brightness of the idli colour gradually decreased when the black gram dhal percentage was raised (Durgadevi & Shetty, 2012a) [5].

**Table 3:** Pearson correlation matrix among color characteristics (n=28, $p<0.05$)

| | L* | a* | b* |
|---|---|---|---|
| L* | 1 | | |
| a* | -0.50 | 1 | |
| b* | -0.57 | 0.39 | 1 |

### 3.4 Correlation with ink print test measurements

To capture the appearance of idli through photography of ink prints, "ink print test" was carried out. These prints provide a measure of the softness of idlis by displaying the number of pores per square centimetre in graph paper. The measured values are correlated with the sensory scores and the correlation coefficient obtained is shown in table 4. From the table it is clear that number of pores is positively correlated at a significance difference of $p<0.05$ with softness ($r$=0.97), fluffiness ($r$=0.95), flavor ($r$=0.91), taste ($r$=0.89), and overall acceptability ($r$=0.88). As fermentation time increases more air pockets are created due to accumulation of $CO_2$. This increases the softness and fluffiness of idli samples. This demonstrated that the placement of air pockets created a textural variance in the idli samples (Chelliah *et al*., 2016) [4].

**Table 4:** Correlation analysis of number of pores with sensory score

| | No. of pores | Appearance | Color | Flavor | Softness | Fluffiness | Stickiness | Taste | Overall acceptability |
|---|---|---|---|---|---|---|---|---|---|
| No. of pores | 1 | 0.47 | 0.2 | 0.91 | 0.97 | 0.95 | 0.23 | 0.89 | 0.88 |

### 3.5 Principal component analysis (PCA)

PCA analysis was performed on the sensory and textural scores. Figure 1 a) is the obtained loading plot from PCA analysis of textural parameters. 84% of the variation in the data matrix is explained by PC1 and PC2. PC1 contributes 56.07% and PC2 contributes 28.17%. Textural characteristics that fall on PC1's "positive" side include cohesiveness, chewiness, gumminess, and hardness, whilst its "negative" side is represented by springiness. Resilience was falling nearly to the centre. All these results are on par with the correlation obtained. PCA analysis for sensory scores (Figure 1 b) shows that seven out of eight sensory properties falls on the positive side of PC1 and only stickiness fall on negative side of PC1. 70% of the data matrix's total variance is explained by PC1 and PC2, respectively. The extracted eigenvector values of textural and sensory scores are given in table 5 and table 6.

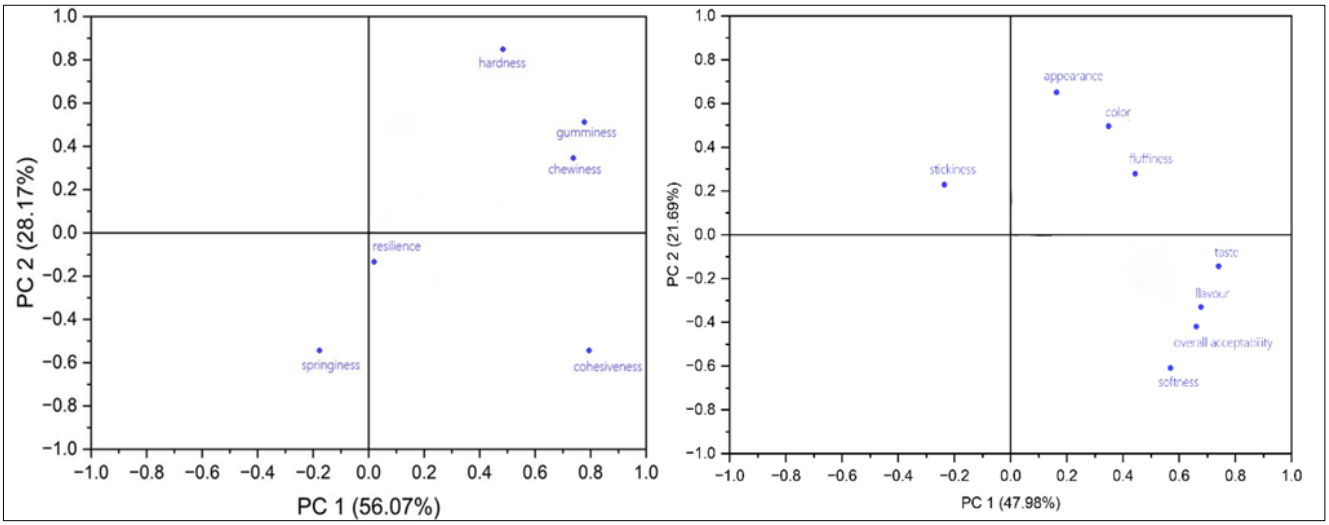


**Fig 1ab:** PCA analysis 1 a) loading plot for textural properties, 1 b) loading plot for sensory attributes

**Table 5:** Eigenvectors of PCA analysis for sensory attributes

| | Coefficients of PC1 | Coefficients of PC2 |
|---|---|---|
| Appearance | 0.12 | 0.72 |
| Color | 0.34 | 0.53 |
| Flavor | 0.63 | -0.41 |
| Softness | 0.56 | -0.68 |
| Fluffiness | 0.25 | 0.41 |
| Stickiness | -0.21 | -0.24 |
| Taste | 0.47 | -0.02 |
| Overall acceptability | 0.62 | -0.48 |

**Table 6:** Eigenvectors of PCA analysis for textural characteristics

| | Coefficients of PC1 | Coefficients of PC2 |
|---|---|---|
| Hardness | 0.45 | 0.86 |
| Springiness | -0.21 | -0.62 |
| Cohesiveness | 0.78 | -0.58 |
| Gumminess | 0.77 | 0.54 |
| Chewiness | 0.72 | 0.33 |
| Resilience | 0.01 | -0.15 |

## 4. Conclusions

The obtained values from textural analysis, color characteristics, and sensory attributes of cooked idli was subjected for Pearson correlation. Most of the parameters in the TPA test for idli have favourable correlations. The hardness rating exhibits the softness of idli by having a positive correlation with gumminess and chewiness. There is no relationship between resilience and the other TPA factors. The first principal component of the PCA has a strong positive correlation with cohesiveness, chewiness, and gumminess. Hardness and springiness have a positive and negative correlation with the second principal component, respectively. Resilience had a negligible contribution to either of these principal components. Among the sensory parameters most of the parameters had significant correlation with overall acceptability. And majority of the parameters fall in to the positive side of PC1. Among the color parameters L* and b* values were negatively correlated. Number of pores obtained by ink print method had significant correlation with sensory properties. Therefore with the rising sophistication of today's idli or similar food product production and the growing need for improved quality monitoring of such items, this study may be employed further as a tool for further categorization of idlis.

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