STUDIES ON STANDARDIZATION AND DEVELOPMEN OF INNOVATIVE FINGER MILLET FORTIFIED *IDLI*

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Abstract

Idli, cereal and legume based Indian traditional fermented food product is widely consumed as breakfast food. Finger millet, an underutilized nutritious cereal is rich in calcium, phenols and fibres. Brown rice being rich in thiamine, riboflavin, tochopherol, calcium is more healthy option for idli as compared to white rice. The present investigation was undertaken to standardize and develop finger millet fortified idli along with brown rice. The different samples were formulated with partial replacement of white rice and dehulled spilt black gram by brown rice and finger millet respectively. The samples were prepared with 21% brown rice was observed to be sensorially as compared to other levels hence this sample is further fortified with finger millet. Four samples were formulated with fortification of finger millet from by varying levels from 0 to 20% and overall acceptability of samples judged by semi-trained panel members found in between 6.7 to 7.6. On the basis of chemical analysis of the finger millet fortified samples shown increase in crude fiber, carbohydrates and calcium content.

Key Words: Finger millet, brown rice, fortification, idli, Indian traditional food product

1. Introduction

Traditional fermented foods are widely consumed all over India. Generally, these are formulated from local food crops and other resources which are easily available. Fermented foods such as *idli* were described as early as 700 BC. There are many fermented foods with different base material and different preparation methodologies are available at the present time. There is a unique group of micro-biota for each fermented food, and these micro-biota increases the level of proteins, vitamins, essential amino acids and fatty acids in the product. However, fermented foods are still produced traditionally by spontaneous fermentation and only limited knowledge has been obtained regarding the micro-biota of these products (Jeyaram *et al*., 2009).

Fermentation, a most economical and one of the oldest food processing technology. Fermentation process helps in enhancing the nutritional value of food through the synthesis of essential amino acids and vitamins. Fermentation assist in reducing the volume of material to be transported and also reduces the energy required for subsequent cooking of preserved product (Simango, 1997). Destruction of undesirable substances present in raw foods such as phytates, tannins takes place due to fermentation resulting in detoxification (Gadaga *et al.*, 1999).

Cereal-based fermented foods are considered as staple diets in their respective regions. *Idli, dosa, dhokla, koozhu, nan, parotta, ambali, pazhaiya, soru* are the daily consumed foods by the local population. They are mostly made at the household level and have a short shelf life (Satish Kumar *et al*., 2012).

Idli, a cereal legume-based fermented product, is a white, soft, spongy textured product which is widely consumed in entire south India as a traditional breakfast food (Sridevi *et al*., 2010). Fermented foods such as *idli* were described as early as 700 BC. *Idli* is produced by a blend of fermented rice (*Oryza sativa*) and dehulled black gram (*Phaseolus mungo*). The ratio of rice to dehulled black gram is 2:1. Rice and dehulled black gram are soaked separately in processing. After draining water, rice and dehulled black gram, ground independently with occasional addition of water during the *idli* batter preparation. The rice is coarsely ground, and the dehulled black gram is finely ground. Then the rice and the dehulled black gram batters are mixed together with the addition of little salt and allowing it to ferment overnight at room temperature. Finally, the fermented batter is placed in special *idli* pans and steamed for 5-8 minutes (Blandino *et al.*, 2003). The *idli* so prepared is served hot.

Idli helps in weight loss as a single piece of *idli* has only 39 calories. It is light and easy to digest making it a good snack. It is rich in vitamins as the fermentation increases the bioavailability of the proteins and vitamins. Lactic acid bacteria can increase levels of vitamins in food, especially B vitamins. It also encourages healthy gut flora. *Idli* is easy to digest as the complex sugars are converted into simple sugar during fermentation. The probiotic microbes like *Lactobacillus plantarum* and *Lactobacillus lactis* are present in batter and these bacteria produce vitamin B12 and β-galactosidase enzyme which promotes health. (Iyer *et al*., 2013) The fermented foods increase the absorption of vital minerals from gastrointestinal tract, thus preventing mineral deficiencies.

Finger millet (*Ragi*) varieties with yellow, white, tan, red, brown or violet color are available. However, only the red colored ones are commonly cultivated worldwide. It is a rich source of carbohydrates and comprises of free sugars (1.04%), starch (65.5%) and non-starchy polysaccharides or dietary fiber (11.5%) (Gopalan *et al*., 2009). Prolamins are the major fractions of finger millet protein. Finger millet is exceptionally rich in calcium (344mg%), potassium (408mg%) compared to all other cereals and millets and also contains phosphorus and iron. Finger millet, in general, and the seed coat in particular, contain several phytochemicals that may have health benefits. Finger millet is rich in calcium. So, it helps in keeping the bones and teeth healthy

and helps in fighting osteoporosis. It helps in controlling diabetes as its seed coat is abundant in polyphenols and dietary fibers as compared to rice, maize or wheat. It helps in fighting anemia as it is rich in iron.

Brown rice is rich has a good amount of calcium, phosphorus, niacin, and tocopherol. The fiber in brown rice helps lower cholesterol, moves waste through the digestive tract, promotes fullness, and may help prevent the formation of blood clots. Brown rice is "low glycemic index" food. The phytochemicals and minerals found in whole grains may help improve cholesterol levels, and reduce the risk of heart disease, stroke and type 2 diabetes, according to AHA (American Health Association).

As the life has become fast, consumers have shifted their focus more on healthy and nutritious food. Consumers want more delicious and nutritious variation of the traditional foods. So, in the present investigation was undertaken the *idli* which is a Indian cereal and legume breakfast food has been fortified with finger millet and brown rice. Finger millet which is underutilized cereal and has many health benefits like high phenol content, rice in fibres and high calcium content. The brown rice is low-glycaemic food and rich in fibres. Compared to white rice brown rice contains more thiamine, riboflavin, tocopherol, phosphorus, iron and zinc (Juliano 1985; Pedersen and Eggum 1983).

2. Materials and Methods

2.1 Materials

2.1.1 Ingredients

The raw materials white rice, brown rice, finger millet and dehulled black gram were procured from the local market of Pune.

2.1.2 Instruments

The instruments like weighing scale, thermometer, hot air oven, kjeltron, fibrotron were used from MIT College of Food Technology to perform different tests.

2.2 Methodology

2.2.1 Determination of Moisture Content

Moisture content was estimated by method given by Ranganna (1995).

Formula

$$\%\text{Moisture} = \frac{\text{Initial weight - Final Weight}}{\text{Initial Weight}} \times 100$$

2.2.2 Determination of Protein

Protein content was determined by Kjeltron apparatus and operational procedure given by Ranganna (1995).

Formula

$$\%\text{N} = \frac{(\text{Sample-Blank}) \times \text{Normality of } H_2SO_4 \times \text{Vol. made for distillation} \times 0.014 \times 100}{\text{Aliquot taken for distillation (ml)} \times \text{weight of sample (g)}}$$

$$\text{Total Protien} = \%\text{N} \times 6.25$$

2.2.3 Determination of Ash Content

Ash content was determined by method described by Ranganna (1995).

Formula

$$\%\text{Ash} = \frac{\text{Final weight}}{\text{Initial weight}} \times 100$$

2.2.4 Determination of Fat content

Fat content was estimated by using soxtron apparatus and procedure given by Ranganna (1995).

Amount of fat present in the sample can be calculated as-

$$\%\text{Fat} = \frac{W_2 - W_1}{W} \times 100$$

2.2.5 Determination of Fibre

Fibre content was determined by fibrotron apparatus and method given by Ranganna (1995).

Fiber content was determined by using following formula

$$\%\text{Crude fiber} = \frac{\text{Weight of residue-Weight of ash}}{\text{Weight of sample}} \times 100$$

2.2.6 Determination of Calcium

Calcium content was determined by method given by Ranganna (1995).

1 ml of 0.01N KMnO4 = 0.2004 mg calcium.

2.2.7 Total Phenol Content

The *idli* samples were dried at 30ºC for 12 h first and the ground to make fine powder. The prepared powder was extracted with 80% aqueous methanol (1g/10mL) for 2 h at 37ºC.

The samples were then centrifuged at 10000 RPM for 15 minutes. The supernatant collected was used for measuring total phenol content using Folin-Ciocalteu method (Lowry *et al.* 1951) The absorbance was measured at 750 nm. (Das *et al.* 2013)

2.2.8 Antioxidant by DPPH method

The antioxidant activity of the extracts on the basis of the scavenging activity of the stable 1,1-Diphenyl-Picrylhydrazyl (DPPH) free radical was determined by the method described by Sreelatha and Padma (2009).

Aqueous methanolic extract (0.1 mL) was added to 3 ml of a 0.04% solution of DPPH. Absorbance at 517 nm was determined after 30 minutes and the percent inhibition was calculated as

$$\% \text{ Inhibition} = \frac{A_0 - A_e}{A_0} \times 100$$

(A_0= Absorbance without extract, A_e= Absorbance with extract)

2.3 Evaluation of Fermented batter

2.3.1 pH and Density of batter (g/cm^3)

The pH of fermented batters was measured using pH meter. The batter density was measured using pycnometer.

2.3.2 Acidity

The acidity of fermented batters was measured using the titration method and using NaOH as the titrating chemical and phenolphthalein as indicator.

2.3.3 Increase in Volume

The increase in volume of batters was analysed by putting the prepared batter in measuring cylinder and fermenting it for 20 hours.

The increase in volume was calculated by following formula

$$\text{Increase in Volume} = \frac{\text{Volume after fermentation} - \text{Volume before fermentation}}{\text{Volume before fermentation}} \times 100$$

2.3.4 Texture profile analysis

Texture profile analysis of *idli* was done using Brookfield CT3 Texture Analyzer using wire probe.

2.4 Microbiological Analysis Assay

2.4.1 Yeast and mould count

It was determined by the method given by Yadav *et al.* (2014).

2.4.2 Total Plate Count

It was determined by the method given by Yadav *et al.* (2014).

2.5 Sensory Analysis

Sensory analysis of prepared *idli* samples were done using 9-point hedonic scale rating. (Das *et al.* 2013)

2.6 Preparation of *Idli*

2.6.1 Preparation of brown rice fortified *Idli*

The white rice, brown rice and dehulled black gram were separately soaked for 4 hours and after that they were ground separately with addition of water and mixed together to prepare batter. These prepared batters were subjected to fermentation for 20 hours (Hemavathi *et al.* 2017). After fermentation salt was added at the rate of 1% of overall weight and stirred well. The batter was poured into greased *idli* mould and steamed for 15 minutes. The *idli* pieces were demoulded and cooled to room temperature.

Table 1. Proportion of idli ingredients in brown rice fortified idli

Samples	Ingredients (%)		
	Rice	Brown Rice	Black gram
B_0	70	-	30
B_1	49	21	30
B_2	42	28	30
B_3	35	35	30

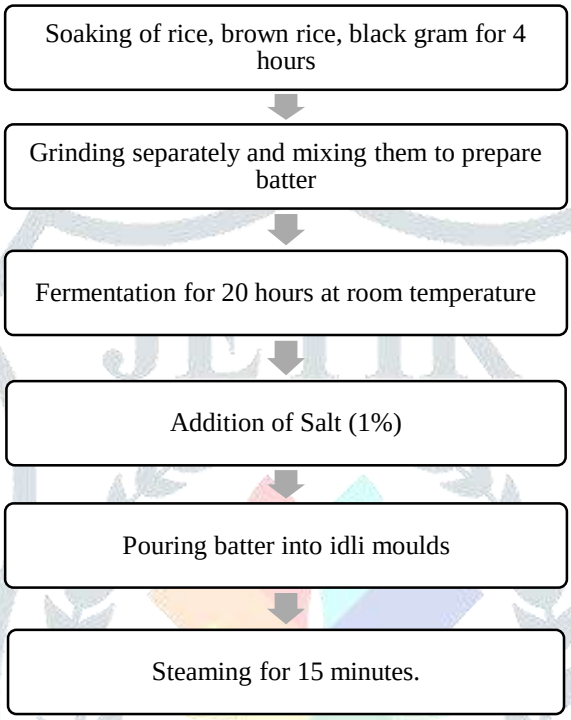

Figure 1. Processing technology of brown rice fortified idli

2.6.2 Preparation of brown rice and finger millet fortified *Idli*

The white rice, brown rice, dehulled black gram and finger millet were separately soaked for 4 hours and after that they were ground separately with addition of water and mixed together to prepare batter. These prepared batters were subjected to fermentation for 20 hours (Hemavathi *et al.* 2017). After fermentation salt was added at the rate of 1% of overall weight and stirred well. The batter was poured into greased *idli* mould and steamed for 15 minutes. The *idli* pieces were demoulded and cooled to room temperature.

Table 2. Proportion of *idli* ingredients in brown rice and finger millet fortified *idli*

Samples	Ingredient (%)			
	Rice	Brown Rice	Black gram	Finger millet
R_0	70	-	30	
R_1	49	21	20	10
R_2	49	21	15	15
R_3	49	21	10	20

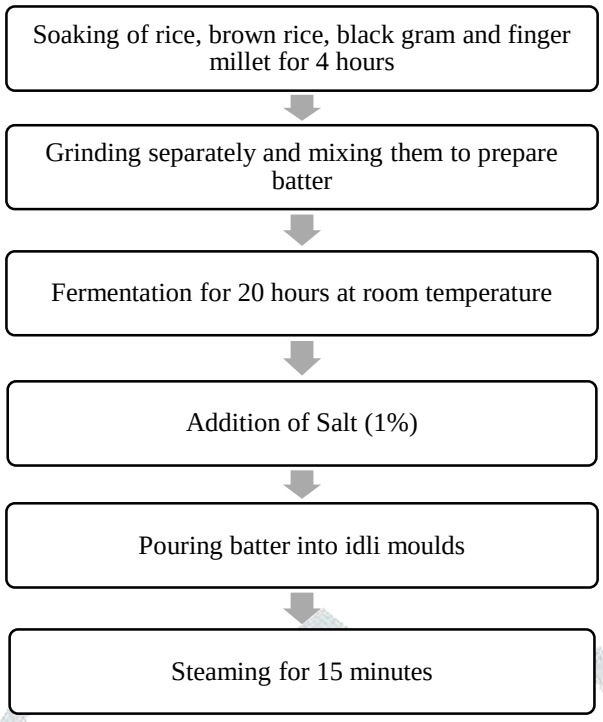

Figure 2. Processing technology of brown rice and finger millet fortified idli

3. Results and Discussion

3.1 Chemical Properties

Table 2. Chemical Parameters of Raw Material

Parameters (%)	Ingredients			
	Brown rice	White rice	Finger millet	Black gram
Moisture	10.24	11.52	12.96	11.23
Protein	8.24	6.38	7.12	23.67
Crude Fat	2.84	0.51	1.26	1.68
Carbohydrates	76.61	79.74	72.66	57.23
Crude Fiber	0.64	0.34	3.27	1.08
Ash	1.13	0.63	2.73	3.16
Calcium (mg/100 g)	21.13	24.56	333.27	123.56

The highest value of moisture was found in finger millet (12.96 %) and lowest was of brown rice (10.24 %). There is not much big difference in the moisture content of white rice (11.52%) and black gram (11.23%). The protein content, a body building unit of black gram (23.67%) was observed highest followed by brown rice (8.24%), finger millet (7.12%) and white rice (6.38%). The lowest crude fat was observed in white rice (0.51%) whereas brown rice has more fat (2.84%). This may be due to the presence of bran layer in brown rice contributes in fat content. The amount of carbohydrates present in black gram, finger millet, brown rice and white rice is 57.23, 72.66, 76.61 and 79.74 percent respectively. The crude fiber, a digestive track cleanser is highest in finger millet (3.27 %) making the product more nutritious. The fiber content of brown rice (0.64%) is more than white rice (0.34%) indicates its importance in fullness index and satiety value. Black gram contains 1.08 percent fiber. Rice has the lowest ash value (0.63%) whereas, black gram has highest ash (3.16%). The highest calcium 333.27 mg/100 g is present in finger millet followed by black gram (123.56 mg/100 g), white rice (24.56 mg/100 g) and brown rice (21.13 mg/100 g).

3.2 Chemical analysis of fermented *idli* Batters

Table 3. Chemical Analysis of fermented finger millet *idli* batters

Samples	Parameters			
	pH	Acidity (%)	Density (g/cm^{-3})	Increase in Volume (%)
R_0	5.6	0.49	0.64	60
R_1	5.4	0.57	0.75	50
R_2	5.2	0.63	0.79	30
R_3	5.1	0.68	0.81	20

Where,

R_0 = 0% brown rice, 0% Finger millet, R_1 = 21% brown rice, 10% Finger millet

R_2 = 21% brown rice, 15% Finger millet, R_3 = 21% brown rice, 20% Finger millet

The pH of the batter varies from 5.1 to 5.6. The acidity ranges from 0.49 to 0.68 percent of lactic acid. There is minor difference in pH of samples R_1, R_2 and R_3. The density of the samples R_0, R_1, R_2 and R_3 is 0.64, 075, 0.79 and 0.81 g/cm^{-3} respectively. The volume increase of batter was decreased with the increase in the amount of finger millet and also it was affected by the room temperature as the room temperature is less in monsoon and winter season. The range of increase in volume is 20 to 60 percentage.

3.3 Effect of brown rice and finger millet fortification on sensory characteristics

3.3.1 Effect of brown rice fortification on sensory characteristics of idli

Table 4. Sensory Profile of Brown Rice Fortified Idli

Sample	Parameters				
	Appearance	Color	Taste	Texture	Overall Acceptability
B_0	8.3	8.3	8.1	8.2	8.2
B_1	8	7.9	8	8	8.1
B_2	7.4	7.3	7.5	7.4	7.4
B_3	6.9	6.8	7.0	6.8	6.9

*Each value is average of ten observations

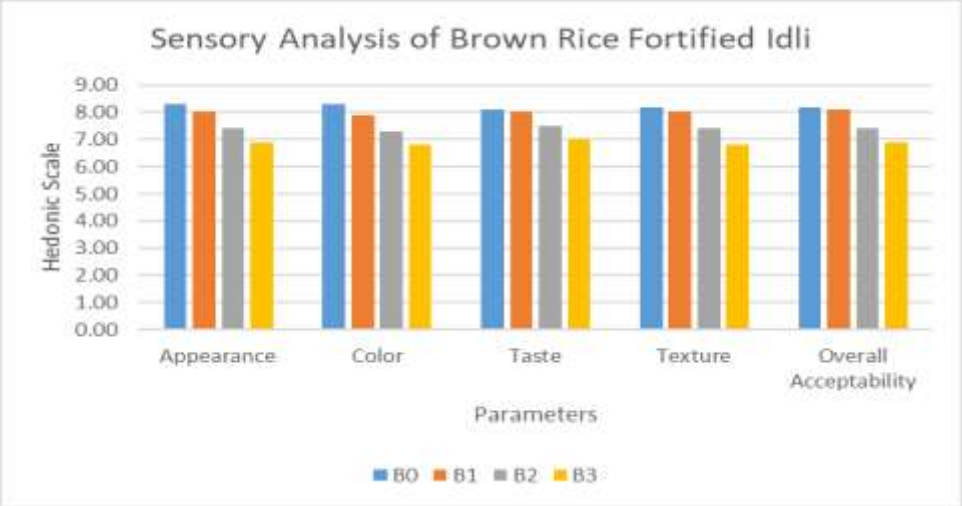

Figure 3. Sensory analysis of brown rice fortified idli samples

Where,

B_0 = 0% brown rice, B_1 = 21% brown rice

B_2 = 28% brown rice, B_3 = 35% brown rice

The organoleptic characteristics of brown rice fortified idli samples were evaluated by semi-trained panel using 9-point hedonic scale and the average scores are tabulated in table no. 5.

As per table, appearance and color scores are decreasing from 8.3 to 6.9 and 8.3 to 6.8 respectively. This may be due to brown color contribution of brown rice. The brown rice has a bit of muddy taste and because of this the value of taste is reducing from B_1(8) to B_3(7). The scores of texture ranges from 6.8 to 8.2 and overall acceptability ranges from 6.9 to 8.2. The overall acceptability scores (8.1, 7.4, 6.9) and other sensory attributes score was found to be highest in B_1 as compared to other two samples, hence the 21% of brown rice proportion is further selected for fortification of finger millet.

3.3.2 Effect of brown rice and finger millet fortification on sensory characteristics

Table 5. Sensory Profile of Finger millet and Brown Rice Fortified *Idli*

Sample	Parameters				
	Appearance	Color	Taste	Texture	Overall acceptability
R_0	7.9	8.0	8.2	8.1	8.1
R_1	7.9	7.6	7.6	7.7	7.6
R_2	7.5	7.3	7.6	7.5	7.6
R_3	7.3	7.0	7.7	6.6	6.7

Where,

R_0 = 0% Brown rice, 0% Finger millet, R_1 = 21% Brown rice, 10% Finger millet,

R_2 = 21% Brown rice, 21% Finger millet, R_3 = 21% Brown rice, 20% Finger millet

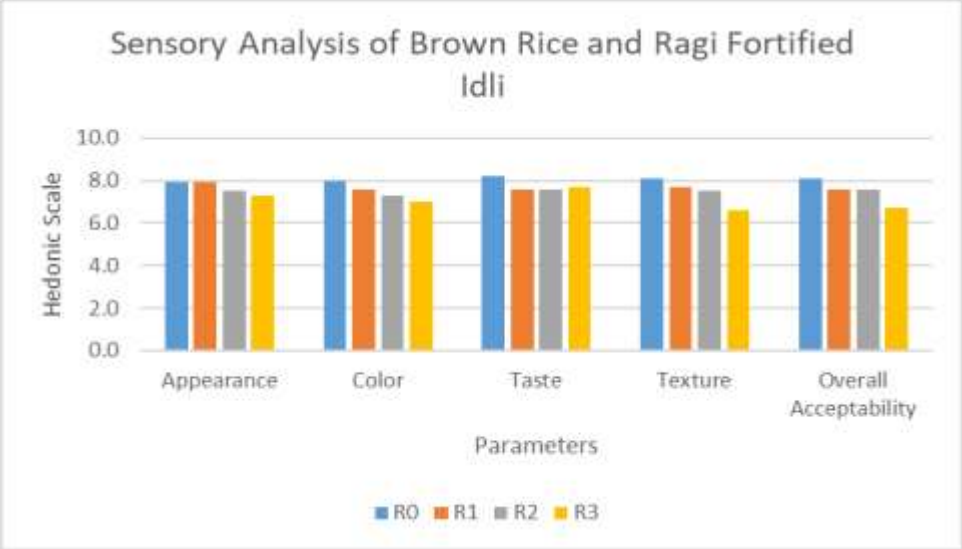

Figure 4. Sensory analysis of brown rice and finger millet fortified idli samples

The Appearance ranged from 7.3(R_3) to 7.9(R_0). The appearance value of sample R_0(7.9) and R_1 (7.9) is same whereas the value of R_2 and R_3 are reducing with the increase of finger millet percentage. The highest value of color is 8.0(R_0) and lowest is 7.0(R_3). The value of color reduces with the increase of finger millet percentage. The reduction in appearance and color values are due to the reddish color of finger millet and husk. The taste value of samples R_0, R_1, R_2 and R_3 are 8.2, 7.6, 7.6 and 7.7 respectively. The texture ranges from 6.6(R_3) to 8.1(R_0) and with the increase in the percentage of finger millet the value of texture is reduces. Overall acceptability of sample R_1 and R_2 are same i.e 7.6, but other sensory attribute scores of sample R_1 are higher than R_2. Hence, fortification of finger millet with 10% proportion was sensorially acceptable and can be successfully fortified.

3.4 Chemical Parameters of finger millet fortified *idli* samples

Table 6. Effect of finger millet fortification of chemical parameters of *idli* samples

Parameters (%)	Samples			
	R_0	R_1	R_2	R_3
Moisture	56.59	52.0	50.66	49.9
Protein	12.36	9.79	9.47	8.64
Crude Fat	0.12	0.22	0.20	0.24
Carbohydrates	30.1	36.99	37.29	38.78
Crude Fiber	0.51	1.20	1.39	1.48
Ash	0.41	1.1	0.99	0.96

Calcium (mg/100 g)	51.26	70.51	82.99	93.48

It is evident from the table the moisture content is reducing with the increasing amount of finger millet. The Moisture ranges from 49.9 to 56.59. It may be due to the less water absorption capacity of finger millet and brown rice. The protein content of control sample R_0 was highest 12.39%. The value of protein was reducing gradually for samples R1 (9.79%), R2 (9.47%), and R3 (8.46%). The reason for reduction in protein content is due to replacement of black gram with finger millet. The Crude fat values for samples are in the range of 0.12 to 0.24 percent. The value of carbohydrates increases with the increase in the amount of finger millet. The highest value is of carbohydrates was found in R_3 (38.78%) whereas, lowest in sample R_0 (30.1). The highest crude fiber is present in sample R_3 (1.48%) it may be due to fiber content of finger millet. The highest percentage of ash is present in the sample R_1 (1.1%) and lowest is in sample R_0 (0.41%). There is minor difference in the ash percentage for the sample R_2 and R_3. The calcium value is increasing with the increase in the percentage of finger millet in *idli* as the finger millet is rich in calcium. The calcium value was observed highest in sample R_3(93.48 mg/100 g) followed by R_2 (82.99 mg/100 g, R_1 (70.51 mg/100 g) and R_0 (51.26 mg/100 g). This may be due to increasing quantity of finger millet in *idli* batter.

3.5 Effect of Finger millet and Brown rice fortification on total phenol and antioxidant activity of prepared *idli* samples

Table 7. Total Phenol and Antioxidants profile of prepared *idli* samples

Samples	Total Phenols (mg of GAE/100g)	Antioxidants (mg of ascorbic acid/l)
R_0	147.7173	29.40299
R_1	159.71767	52.53731
R_2	162.79469	57.76119
R_3	166.17941	65.37313

The simple trend can be identified from the table that values of antioxidant and total phenols are increasing with the increase in the content of finger millet. The total phenol content of R_0, R_1, R_2 and R_3 are 147.71, 159.71, 162.79 and 166.17 mg of GAE/100 g respectively. The antioxidants value ranges from 29.40 mg of ascorbic acid/l (R_0) and 65.37 mg of ascorbic acid/l (R_4).

3.6 Texture analysis of finger millet fortified *idli* samples

Table 8. Texture profile of control and finalized finger millet fortified *idli* sample.

Parameters	Samples	
	R_0	R_1
Hardness (g)	144	222
Adhesiveness (mJ)	0.6	0.5
Resilience	0.15	0.11
Cohesiveness	0.28	0.89
Springiness (cm)	0.890	0.838
Chewiness(mJ)	3.5	16.3

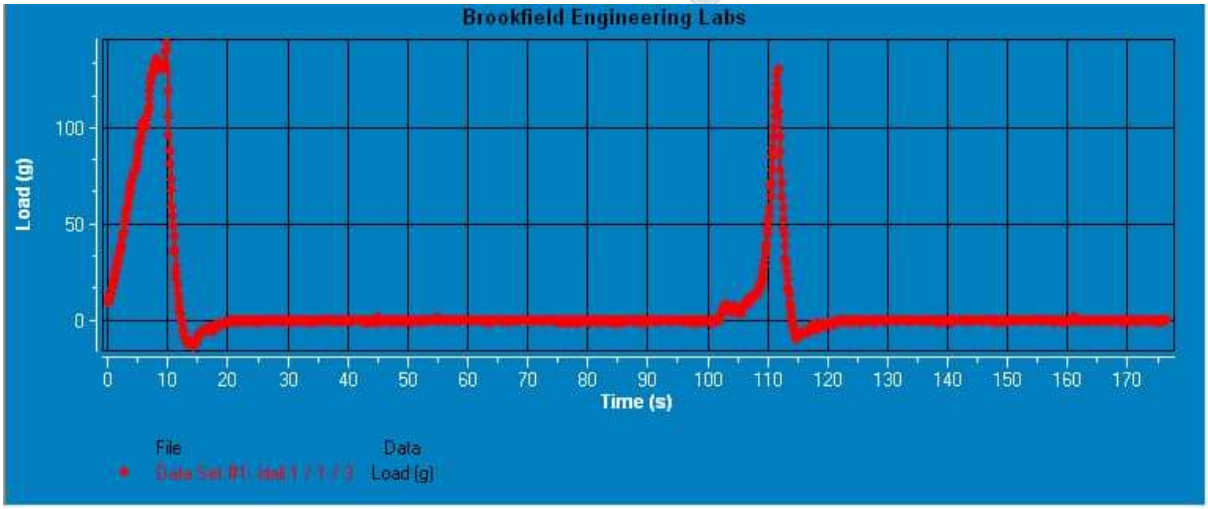

Figure 5. Texture profile analysis graph of sample R_0

Figure 6. Texture profile analysis graph of sample R_1

The hardness of sample R_1 is more than the sample R_0 as the moisture content of sample R_1 is less compared to sample R_0. The addhesiveness of sample has reduced with the addition of ragi which means that sample R_1 requires less time to get back to its original shape after the deforming force is removed. The value of resilance and springiness shows that the sample R_1 recovers faster from deformation compared to sample R_0. Cohesiveness of sample R_1 has incresed which signifies that the strength of the internal bonds making the product's body is high for sample R_1. The chewiness of the sample R_1 (16.3 mJ) is more than the sample R_0 (3.5 mJ). The results of chewiness signifies that the sample would require more energy to chew the solid product till it is ready for the swallowing. The springiness and resilance of sample R_0 and R_1 is 0.15 and 0.11.

3.7 Microbial Assessment of finger millet fortified samples

Table 9. Microbial assessment of finger millet fortified *idli*

Samples	Microbiological Parameters (cfu/ml)	
	Total Plate Count	Yeast and Mold Count
R_0	90	<10
R_1	71	<10
R_2	86	<10
R_3	75	<10

Where,

R_0 = 0% brown rice, 0% Finger millet, R_1 = 21% brown rice, 10% Finger millet

R_2 = 21% brown rice, 15% Finger millet, R_3 = 21% brown rice, 20% Finger millet

Control and finger millet fortified *idli* samples were assessed for total plate count and yeast and mold count and results obtained are presented in table

It is revealed from the table the total plate count of prepared *idli* samples was in the range of 71 to 90 cfu/ml. The yeast and mold count of all samples were less than 10 cfu/ml. From the table it can be concluded that microbial load of given samples is within specified limit.

4. Conclusion

In the study, firstly the partial replacement of white rice was done by brown rice by 21, 28 and 35% where the sample with 21% replacement was selected for further fortification based on the sensory analysis. After fixing the brown rice content different samples were prepared with white rice 49%, brown rice 21% and the partial replacement of dehulled black gram with finger millet. The samples were prepared with 10,15 and 20% replacement where the sample with 10% finger millet was selected as the best sample on the basis of sensory analysis. The study data signifies that the incorporating brown rice and finger millet in *idli* by replacement method increases the fiber content and calcium content. It also increases the total phenol and antioxidant activity has increased with the incorporation. Though the texture analysis shows that the fortified *idli* has a bit hard texture it is acceptable in sensory.

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