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Manisha
Department of Foods & Nutrition COHS, CCSHAU Hisar, Haryana, India

Sangeeta C Sindhu
Department of Foods & Nutrition COHS, CCSHAU Hisar, Haryana, India

Urvashi Nandal
Department of Foods & Nutrition COHS, CCSHAU Hisar, Haryana, India

Corresponding Author:
Sangeeta C Sindhu
Department of Foods & Nutrition COHS, CCSHAU Hisar, Haryana, India

Brown rice *Idli*: Development and evaluation of a low Glycemic index Indian breakfast food

Manisha, Sangeeta C Sindhu and Urvashi Nandal

Abstract
The present study was planned to develop and evaluate *Idli* with low glycemic index. *Idli* is a popular fermented breakfast food consumed in the Indian subcontinent mainly south India. Over the time period, it has also become popular in Northern India due to ease of making and its savoury taste. It is conventionally made mainly of rice and black gram. In order to make it diabetic friendly, *Idli* was developed using brown rice, soybean, *Acacia nilotica* and *Coccinia indica*. The Idli developed using brown rice in combination with black gram and soybean was found to be highly acceptable. Nutritional evaluation revealed 10.82 g/100g protein, 4.43 g/100g fibre. Antioxidant activity was analyzed in terms of phenolic content (5.32 mg GAE/100g) and DPPH radical scavenging activity (6.32 TE/100g). *In-vitro* starch and protein digestibilities were found to be 65.18 mg maltose/g and 79.46 percent, respectively. Percent mineral availability was in the range of 55 to 66 for different minerals. Glycemic index was found to be 50.83. The *Idli* incorporated with Coccinia *indica* and *Acacia nilotica* were not found acceptable.

Keywords: Brown rice, fermented product, nutritional evaluation, sensory evaluation, glycemic index

Introduction
Idli is a popular fermented breakfast food consumed in the Indian subcontinent mainly south India. Over the time period, it has also become popular in Northern India due to ease of making and its savoury taste. It is conventionally made mainly of rice and black gram.
Brown rice or 'hulled rice' known as whole grain rice, from which the germ and outer layers containing the bran have not been removed is richer in nutritional components, such as protein, fat, vitamins, and minerals. It has glycemic index lower than that of conventionally processed rice [1, 2]. Also, the whole brown rice grain has shown a greater content of bioactive compounds such as phenolic acids, flavonoids, γ - oryzanol, aminobutyric acid (GABA), α-tocopherol, and γ – tocotrienol [3-5]. Mice and cellular experiments have revealed that brown rice specific γ - oryzanol acts as a molecular chaperone, ameliorates reticulum stress in hypothalamus, protects β-cells against apoptosis, and inhibits DNA methyl transferases in brain reward system [6, 7].
Soybean, *Coccinia indica* and *Acacia nilotica* are some of the well-known food products with antidiabetic acivity. Soya products are also known to have low glycemic index, thereby bearing beneficial effects in diabetes mellitus due to the dietary fiber content of soyabeans. Soy products are rich in plant protein, dietary fiber, vitamins, polyunsaturated fatty acids and phytoestrogens [8]. *Coccinia indica* is a creeper which has been used in *ayurvedic* medicine in Sri Lanka and India to treat diabetes from ancient times [9]. It shows presence of various chemical constituents such as alkaloids, carbohydrates, glycosides, phenolic compound, gums, mucilages, triterpenoids, flavonoids, anthraquinones and polysaccharides [10]. *Acacia nilotica* has been confirmed as anti-diabetic [11] and legumes of this plant are known to cause hypoglycemia by stimulating insulin secretion in the islets of Langerhans through direct or indirect effects on β-cells [12].
Considering the fact that diabetes prevalence has increased by 64% across India during the last quarter of century, a healthy lifestyle along with low glycemic foods are need of the hour for diabetic as well as pre-diabetic patients (International Diabetes Federation, 2021) [13].
With consideration of above, the present study was planned to develop and evaluate *Idli* with low glycemic index.

Material and Methods
Product Development: Brown rice and other ingredients for product development were purchased from market in a single lot.

Idli was developed using modified method of Balasubramanium *et al*., (2006) [14]. Rice, black gram and soybean were soaked and ground separately with occasional addition of water during grinding process, and then mixed together with addition of a little salt. The mixture was allowed to ferment overnight at room temperature; the fermented batter was dispensed in special *Idli* pans and allowed for steaming for 5–8 min [14].

Two more variants of *Idli viz*. *Idli* B and *Idli* C were developed incorporating the *acacia* pods and *coccinia indica* powder (Table 1).

Table 1: Product Development

Ingredients	*Idli* A	*Idli* B	*Idli* C
Brown rice (g)	65	60	60
Black gram (dehulled) (g)	25	20	20
Soyabean (g)	10	10	10
Kikar Pods Powder (g)	-	-	10
Kundru Powder (g)	-	10	-

Plate 1: *Idli*

Sensory evaluation

The developed *Idli* (s) were evaluated organoleptically in terms of colour, appearance, aroma, texture, taste and overall acceptability using 9 point Hedonic scale by panel of semi-trained judges.

Nutritional evaluation

Moisture, crude fibre and ash content was determined by employing the standard method of analysis [15]. Crude protein was estimated using KEL PLUS Automatic Nitrogen Estimation System. A factor of 6.25 was applied to convert the amount of nitrogen to crude protein. Crude fat was estimated using the Automatic SOCS plus Solvent Extraction System. Total soluble sugars, reducing sugars, starch resistant starch, *in vitro* starch and protein digestibilities were also estimated [16-21]. The amount of non-reducing sugars was calculated as the difference between total soluble sugars and reducing sugars. Total dietary fibre constituents were determined by enzymatic method [22]. The concentration of total phenol of the methanolic extracts was determined by the Folin–Ciocalteau colorimetric method [23]. The amount of flavonoids content in methanolic extracts was determined by aluminium chloride colorimetric method [24]. The antioxidant activity of the extracts was also assessed on the basis of the scavenging activity of the stable DPPH free radical [25] and Ferric Reducing Antioxidant Power (FRAP) Assay [26-27]. Total minerals were analyzed by Atomic Absorption Spectrophotometer AABQ-20. Available minerals were extracted by method of Kim and Zemel (1986) [28]. The data obtained were analyzed statistically by using ANOVA. Critical difference value was used to analyse significance of difference at CD ($p \leq 0.05$).

Results and Discussion

Sensory evaluation: It can be observed from the mean score of organoleptic characteristics of *Idli* (Fig.1) that *Idli* A was adjudged in the category of "liked very much" to "extremely liked" in terms of colour, appearance, aroma, texture, taste and overall acceptability (8.1 to 8.5). However, with the incorporation of *coccinia indica* or *acacia* pods powder, the acceptability of *Idli* B as well as *Idli* C, decreased to "disliked very much" to "disliked slightly" (scoring between 2.4 to 3.9).

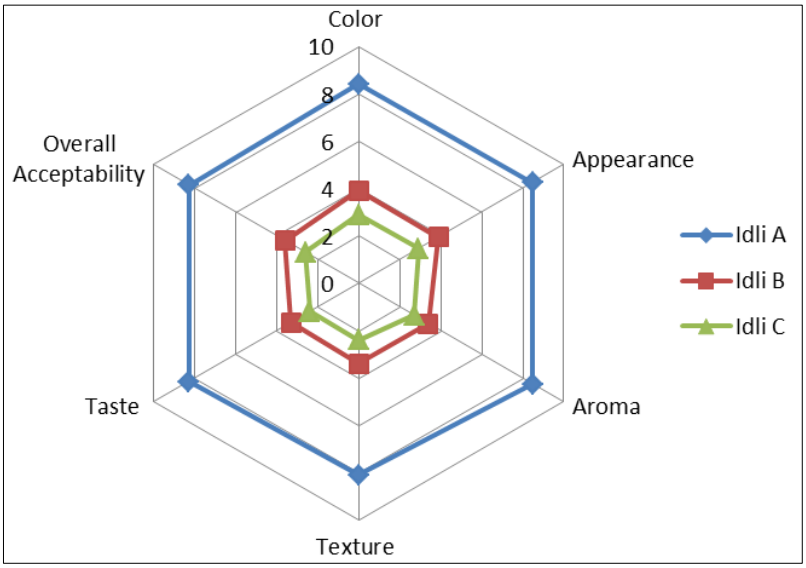

Fig 1: Organoleptic characteristics of *Idli*

Due to the lowest scores of *Idli* B and *Idli* C, these were not subjected to nutritional evaluation and only *Idli* A was subjected to further analysis.

Nutritional evaluation

The moisture, crude fat, ash, crude protein, crude fibre, total and average carbohydrates in *Idli were* found to be 62.29, 4.44, 2.23, 10.82, 3.13, 20.18 and 15.75 g/100g, respectively (Table 2). The total soluble sugar, reducing sugar, non-reducing sugar, starch and resistant starch were 2.94, 0.47, 2.46, 65.27 and 1.04 g/100g, respectively.

Table 2: Proximate and carbohydrate composition of *Idli* (db)

Parameters	*Idli* (g/100 g)
Moisture*	62.29±0.12
Crude Fat	4.44±0.15
Ash	2.23±0.12
Crude Protein	10.82±0.06
Crude Fibre	3.13±0.18
Total Carbohydrates	20.18±0.14
Average Carbohydrates	15.75±0.15
Total Soluble Sugar	2.94±0.04
Reducing Sugar	0.47±0.01
Non Reducing Sugar	2.46±0.01
Starch	65.27±0.01
Resistant Starch	1.04±0.08

Values are mean ± SE of six independent determinations
* Fresh basis

Table 3: Total dietary fiber, antioxidant activity and *in-vitro* digestibility of developed *Idli* (db)

Parameters	*Idli*
Total Dietary Fiber (g/100g)	4.43±0.04
Soluble Dietary Fiber (g/100g)	1.45±0.03
Insoluble Dietary Fiber (g/100g)	2.98±0.09
Total phenols (mg GAE/100g)	61.97±0.04
Total Flavonoids (mg RE/100g)	210.62±0.01
Antioxidant activity DPPH (mg TE/100g)	6.73±0.03
Antioxidant activity FRAP (mg TE/100g)	5.32±0.01
In-vitro starch digestibility (mg maltose/g)	65.18±0.09
In-vitro protein digestibility (%)	79.46±0.43

Values are mean ± SE of six independent determinations

The total, soluble and insoluble dietary fiber content of *Idli* prepared from brown rice was 4.43, 1.45 and 2.98 g/100g, respectively (Table 3). It was observed that total phenol, flavonoids, antioxidant (DPPH) and antioxidant (FRAP) content was 61.97 mg GAE/100g, 210.62 mg RE/100g, 6.73 mg TE/100g and 5.32 mg TE/100g, respectively. *In-vitro* starch and protein digestibilities were found to be 65.18 mg maltose/g and 79.46 percent, respectively.

Table 4: Total, available and percent availability of minerals in *Idli* (db)

Parameters	Total Mineral Content (mg/100g)	Available Mineral Content (mg/100g)	% availability
Iron	1.35±0.04	0.75±0.03	55.55±0.07
Zinc	1.87±0.0.5	1.07±0.03	57.25±0.05
Calcium	10.98±0.23	7.16±0.16	65.46±0.05
Potassium	205.32±0.37	136.45±0.23	66.46±0.05
Magnesium	96.12±0.25	64.17±0.14	66.76±0.03

Values are mean ± SE of six independent determinations

The total iron, zinc, calcium, potassium and magnesium content was observed to be 1.35, 1.87, 10.98, 205.32 and 96.12 mg/100g, respectively and their respective digestibilities were found to be 0.75, 1.07, 7.16, 136.45 and 64.17 mg/100g, respectively (Table 4). The percent availability was 55.55, 57.25, 65.46, 66.46 and 66.76 percent for iron, zinc, calcium, potassium and magnesium, respectively (Table 4).

Glycemic Index

The glycemic index was calculated on the basis of its raw ingredients. Weighted mean of the GI of the raw ingredients i.e. brown rice (65), black gram (25) and soyabean (20) was calculated as the product mean [29, 30]. The glycemic index of the *Idli* developed using brown rice and soybean came out to be 50.83.

Value addition in Idli has attracted the attention of scientists because of its popularity, ease of making and being gluten free. In a similar study, Manickavasagan *et al*. (2013) [31] evaluated the acceptability of *Idli* regarding texture, colour and sensory properties when white rice was replaced with brown rice at five replacement levels (0%, 25%, 50%, 75% and 100%) and more than 90% of the panelists preferred brown rice-blended *Idli* as their first choice.

Similarly Krishnamoorthy *et al*. (2013) [32] tried to enhance nutritional content of *Idli* using germinated millets. They observd 62.20 g/100g moisture, 1.69 g/100g ash, 3.80 g/100g crude fibre and 7.9 g/100g protein. Another study was conducted to develop culturally accepted low glycemic food for the patients of diabetes mellitus [33]. Oat, barley, soybean and chickpea flour were incorporated into the semolina to prepare *idli* by using ten flour combinations. *Idli* prepared from semolina and blended with either soybean or chickpea (75 and 25%) had the highest acceptability score. The results of proximate analysis revealed a significantly ($p \leq 0.05$) higher fibre, protein and a significantly ($p \leq 0.05$) lower carbohydrate content in the developed *idli* from selected blends. The GI of *Idli* prepared from semolina and soy flour (75 and 25%) had significantly lower GI (74.17) as compared to GI of control *idli* (100). Dhillon *et al*. (2020) [34] formulated *Idli* using varying ratios of brown rice and pearl millet flours. The increased addition of pearl millet four significantly increased the fat, protein, ash and fiber content of the formulated *idlis*. The addition of up to 40% pearl millet four was found acceptable by sensory panel.

Conclusion

Brown rice can be considered as good replacement to the white rice for the *Idli* preparation especially for the diabetic patients. The *Idli* developed in the present study has a glycemic index of 50.83. Overall acceptability of the developed *Idli* was 8.3 (liked very much). The developed product had good *in-vitro* digestibilities (starch and protein) and antioxidant activities. Brown rice and Soybean incorporated *Idli* can be recommended for diabetic and pre-diabetic patients.

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