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"Enhancing Idli Pre-Mix: Incorporation of Black Cumin Seeds (Nigella sativa) for Improved Nutritional and Functional Properties"

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ABSTRACT
Fermented foods and beverages have been integral to human diets for centuries, produced either spontaneously or with the addition of starter cultures. This process Beverages local raw materials from plants or animals, transforming them through the activity of microorganisms. These microorganisms enhance the nutritional and biochemical properties of the raw materials, improving taste, texture, and aroma. The methods of producing and consuming fermented foods vary across different cultures and ethnic groups. Despite their numerous health benefits, the consumption of fermented foods globally is declining due to the effects of globalization and changing dietary habits. In India, some of the most popular fermented foods include idli, dosa, appam, porridge (koozh), dhokla, gundruk, dahi, sinki, rumba, fermented rai, kanji ka, and handua. These foods were traditionally favored for their extended shelf life achieved through acetic acid and alkaline fermentations. Fermentation enriches foods biologically, increasing the content of proteins, essential amino acids, essential fatty acids, and vitamins, while reducing anti-nutrients. This process also enhances flavor and aroma, improves digestibility, and offers various health benefits.

Keywords: Traditional Fermented Food, Breakfast Food, Cereals and Pulses, Digestibility, Low Fat Content, Essential Amino Acids, Vitamins and Minerals.

I. INTRODUCTION

Idli, a well-loved fermented breakfast item, is especially popular in Southern India and Sri Lanka, appreciated for its texture and sensory qualities. This dish is prepared by steaming a batter composed of rice (Oryzasativa) and black gram (Phaseolus mungo) in a 4:1 ratio. The fermentation process of these ingredients is essential for producing a high-quality idli. The duration of fermentation significantly influences the sensory characteristics and nutritional value of the idli, affecting both its flavor and texture. Consuming a combination of cereals and legumes, such as in idli, provides nutritional benefits by ensuring a balanced intake of carbohydrates and proteins. Despite the wide array of traditional fermented foods in India, idli is notable for its higher protein efficiency ratio (PER) and enhanced levels of essential amino acids and vitamins.

1.1 Idli : Idli, a traditional and widely enjoyed fermented breakfast dish in India and other countries, is made from a fermented batter of black gram and rice. This dish is a significant source of protein, calories, and vitamins in the diet. When cooked, idlis are soft and spongy, making them easy to digest and nutritionally beneficial (Adsare et al., 2022)[I].

Idli is renowned for its nutritional advantages, combining black gram dal and rice to offer a balanced intake of proteins and carbohydrates. The traditional preparation process involves soaking the ingredients, grinding them, and allowing the batter to ferment overnight. During fermentation, microorganisms multiply rapidly, surpassing the initial contaminants (L. Roy et al., 2023)[XII].Although the traditional method of preparing idli is intricate, the demand for convenience has led to the increasing popularity of ready-made wet idli batters and instant mixes in the Indian market. Various brands and local suppliers provide these batters. To address price disparities, some manufacturers decrease the proportion of black gram dal and increase the amount of parboiled rice or mix in other rice varieties such as raw rice and mixed rice. However, these practices might not be well-received by consumers. While variations in the batter ratio are not necessarily

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harmful, the increased starch from rice and reduced protein content from dal can affect the idli's taste and texture. Currently, there is no established method to quantify the exact proportions of parboiled rice and black gram dal in the batter (L. Roy et al., 2023)[XII].

1.2 Rice: Rice (Oryzasativa) is one of the oldest cultivated crops, with historical records tracing back to 2800 BC in China. It is a staple food for a large portion of the global population, particularly in Southern and Eastern Asia. Rice contributes to more than one-fifth of the calories consumed by humans worldwide. Its nutritional composition includes approximately 7.37% protein, 2.2% fat, 64.3% available carbohydrates, 0.8% fiber, and 1.4% ash content (Mahmoud et al., 2022)[XIII]. There are various rice varieties such as long grain, Basmati, and Arborio, but only a few are widely cultivated. In India, about 85% of the rough rice produced is processed into edible rice, with total production estimated at 1186.9 MT for the 2022-23 period. Around 10% of rough rice is used to produce rice products like puffed rice and flaked rice, while approximately 5% is kept as seed for the next crop. Milling methods vary from traditional hand pounding and dehusking pedals in remote Asian areas to modern equipment in developing countries (Mahmoud et al., 2022)[XIII]. Rice is a nutritious food source, low in fat and rich in starchy carbohydrates, and is packed with essential vitamins and minerals, including vitamin E, B vitamins (thiamin, niacin), and potassium[XIII].

1.3 Black Gram: Black gram (Phaseolus mungo), also known as urad, is a significant pulse crop in India. The country is the largest producer and consumer of black gram globally. Black gram contains about 26% protein, nearly three times that of cereals, making it a vital source of protein for the vegetarian population in India. It is cultivated over an area of 2.42 million hectares, with an annual production of 0.77 million tonnes and a productivity rate of 324 kg/hectare. In 2022-23, India's total black gram production was 123.6 MT. Black gram belongs to the Leguminosae family and is believed to have originated in India, with references found in ancient texts like Kautilya's 'Arthasasthra' and 'Charak Samhita' supporting this presumption (S. Saritha et al., 2018).
India is the world's leading producer and consumer of black gram, which holds a unique position in Indian agriculture, ranking fourth in production and acreage among pulses. Black gram is a significant protein source for India's vegetarian population, consumed in both split and whole forms, supplementing a cereal-based diet. Common dietary combinations such as dal chawal (pulse-rice) and dal roti (pulse-wheat bread) are staples in the Indian diet. The nutritional value of wheat or rice increases significantly when paired with black gram due to the complementary essential amino acids, including arginine, leucine, lysine, isoleucine, valine, and phenylalanine (S. Saritha et al., 2018).

1.4 Black Cumin

Hazrat Aisha (R.A) narrated that she heard the Prophet Muhammad (PBUH) say, "This black cumin is healing for all diseases except As-Sam." Aisha asked, "What is As-Sam?" He replied, "Death" (Sahih Al-Bukhari, 5687).Nigella sativa L., commonly known as black cumin seed or black seed, is an annual herb in the Ranunculaceae family. Native to Southwest Asia, North Africa, and Southern Europe, it is also cultivated in many Mediterranean and Middle Eastern countries, including Iran, Pakistan, India, Saudi Arabia, Syria, and Turkey. The plant and its seeds are widely used as both an edible herb and spice, with significant medicinal applications. Black seed oil is particularly popular in traditional medicine for treating conditions such as rheumatism, piles, jaundice, dyspepsia, parasitic infestations, and skin diseases. Animal research suggests that black seed oil has antihypertensive, antidiabetic, antimicrobial, anticancer, diuretic, analgesic, anti-inflammatory, and antioxidant properties (Y. Mazahari et al., 2018).

Studies indicate that the seeds and oil of Nigella sativa are extensively used in treating various diseases and ailments. Islamic literature frequently recommends its use due to its healing properties, as endorsed by Prophet Muhammad. The seeds are known by several names, including seeds of blessing, black cumin, black seed, Al-Habba Al-Sauda, Al-Habba Al-Barakah, Siyahdaneh, and Kalonji, and are found globally, especially in the Middle East. Nigella sativa contains key constituents such as thymoquinone (TQ), dithymoquinone (DTQ), thymol-hydroquinone (THQ), thymol (THY), p-cymene, 4-terpineol, and t-anethol. Thymoquinone, its most crucial component, has demonstrated hepatoprotective, anti-inflammatory, antioxidant, cytotoxic, and anticancer properties (Mahek and MdAshfaq, 2022).

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II. NUTRITIONAL IMPORTANCE OF FERMENTED FOOD:-

2.1 Overview of Idli and its Significance as a Breakfast Food

Idli is a white, fermented, acid-leavened, steamed product with a soft and spongy texture, widely popular across South India. Historical records indicate that idli batter fermentation has been practiced since 1100 AD (Angam and Rebika, 2021). Idli and dosa are staple breakfast foods in India and Sri Lanka. Idli is made from naturally fermented batter consisting of washed, soaked, and milled rice (Oryzasativa) and dehulled black gram dhal (Phaseolus mungo) (Anika Shaikh, 2021).

From a nutritional perspective, consuming mixtures of cereals and legumes is beneficial as it enhances the balance of carbohydrates and proteins, as well as essential dietary amino acids. Acidified and leavened foods like idli, dosa, and dhokla represent an interesting group of products made from cereal-legume mixtures. Being a cereal and legume-based fermented product, idli boasts improved nutritional composition due to a higher protein efficiency ratio and increased levels of essential amino acids and vitamins (S. Krisnamoorthy et al., 2013).

2.2 Importance of Fermentation in Idli

The fermentation of idli batter is carried out at an ambient temperature of 25–30°C, which is optimal for desirable fermentation (L. Roy, 2023). The microorganisms responsible for the characteristic changes in the batter have been isolated and identified. Although there is a progressive change in the bacterial flora, the predominant microorganism responsible for souring and gas production is Leuconostocmesenteroides. In the later stages of fermentation, the growth of Streptococcus faecalis and subsequently Pediococcus cerevisiae becomes significant. The fermentation of idli is driven by the leavening action caused by the heterofermentative lactic acid bacterium, L. mesenteroides. It has been established that lactic acid plays a major role in the fermentation of idli batter (ViswanathaAngadi et al., 2021).

2.3 Process Optimization

Fermented foods have been essential components of diets worldwide for centuries due to their high nutritional value, improved sensory qualities, shorter cooking times, extended shelf life, and enhanced flavor and aroma. In India, most fermented foods are region-specific and traditionally prepared at the household level using unique methods (Neha S. and Laxmi A., 2014).

Research has shown that ready-to-reconstitute idlis made from optimized ground batter of black gram and parboiled rice grits (1:4) were dried using various technologies, including cabinet drying (CD), fluidized bed drying (FBD), and microwave drying (MD). These idlis were then packed in polypropylene (PP) and metallized polyester (MP) films and stored at ambient (15-34°C) and 37°C conditions. The drying methods significantly ($p \leq 0.05$) affected the chemical stability, texture, and color of the idlis during storage. FBD idlis exhibited the best chemical stability, followed by CD and MD idlis. MD idlis showed more browning and hardness initially and during storage compared to idlis dried by other methods. All idlis, regardless of drying method, demonstrated a shelf life of 12 months, except for MD idlis, which showed 9 months of stability at 37°C. Microstructural studies revealed that MD idlis had larger open pores and better rehydration characteristics (Muskan Shaikh et al., 2021).

2.4 Nutritional Importance of Black Cumin

Fermentation is crucial in idli preparation as it enhances the nutritional quality and organoleptic value. The preparation and fermentation process transforms the final quality of idli, improving flavor and texture while enhancing digestibility. Idli is nutritionally composed of carbohydrates, proteins, vitamins, and minerals. The nutritional composition and quality of idli vary due to different proportions and varieties of rice and black gram used (Anika Shaikh et al., 2021).

Rice is the primary source of carbohydrates in idli, while black gram contributes oligosaccharides (indigestible sugars) such as raffinose, stachyose, and verbascose. These oligosaccharides can cause flatulence, posing a challenge for elimination. The idli preparation process (soaking, fermentation, and steam cooking) reduces oligosaccharide content by up to 34%. Moreover, when steamed idli was fed to rats at 50% of their basal diet, a lower flatulence rate was observed. These indigestible sugars also possess prebiotic properties, supporting the proliferation of lactic acid bacteria (LAB) as a carbon source (El Sayed A. Mahmoud et al., 2022).

2.5 Value Addition in Idli

Co-fermentation of finger millet with horse gram was conducted to create a cost-effective, protein-rich food (dosa, an Indian breakfast item). Natural fermentation of finger

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millet-horse gram flour blend in various proportions (2:1, 3:1, 4:1, and 5:1) was performed for 24 hours. Biochemical analysis showed a significant pH drop (6.6–4.2) and starch content reduction (25.52%), alongside notable increases in titratable acidity (0.168–1.046%), soluble proteins (1.1-fold), and free amino acids (2.6-fold) at 16 hours. Lactic acid bacteria outnumbered yeast counts throughout fermentation, leading to a decrease in total soluble and reducing sugars. Total essential amino acids increased 1.1-fold at 16-hour fermentation, with protein containing 48.68% essential amino acids. Lysine levels rose from 5.87 to 6.73 g of amino acid/100 g of total amino acids. Dosa prepared from 16-hour fermented batter showed superior sensory attributes at a 4:1 ratio. This newly formulated product could help address protein-energy malnutrition (ViswanathaAngadi, 2021).

Freshly blanched leaves of the drumstick tree (Moringaoleifera) were incorporated into three commonly consumed Indian recipes: mung (Phaseolus aureus), kabulichana (Cicer arietinum), and desi chana (Cicer arietinum). About 20g of leaves were added to 30g of food products. These recipes were found to be acceptable, with overall composite scores ranging from 3.06 to 3.53 (on a scale of 1 to 5). Drumstick leaves are known for being rich in micronutrients and were found to meet 82.5% to 83.3% of the RDA for adult women. This study could facilitate the industrial production of ready-to-eat foods incorporating drumstick leaves (Akshaya et al., 2021).

III. ROLE OF INGREDIENTS USED IN IDLI PRE-MIX

Carbohydrate-rich foods, such as cereals, are a primary energy source in the Asian Indian diet. Idli, a popular fermented product made from rice and black gram, is known for its soft, spongy texture and is widely consumed across the Indian subcontinent. This combination of cereals and legumes offers a balanced intake of carbohydrates and proteins. Beyond basic nutrients, the fermentation process of this cereal-legume product enhances its nutritional value by delivering probiotics, prebiotics, fermentable sugars, and hydrolytic enzymes, all of which promote health.

Method of Preparation of Idli Pre-Mix The dough is prepared, shaped, and cut into rounds with a thickness of 6 mm using a cutter. These are baked at 175°C for 15 minutes (Khetarpaul et al., 2018). For the idli premix, rice and black gram are washed, soaked for 2 hours, and ground separately. Black cumin is cleaned and roasted before grinding. The pastes are mixed, with 1-3% salt added, fermented for 14 hours at room temperature, poured into plates, and transferred to a hot air oven (50-60°C for 1-2 hours). After cooling to room temperature, the mixture is packed in polyethylene bags.

3.1 Materials

3.1.1 Ingredients

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

3.1.2 Instruments

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

3.2 Methodology

3.2.1 Determination of Moisture Content

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

Formula

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

3.2.2 Determination of Protein

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

Formula

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

Total Protien = %N × 6.25

3.2.3 Determination of Ash Content

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

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

3.2.4 Determination of Fat content

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

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The amount of fat present in the sample can be calculated as-

$$\% \text{ Fat} = \frac{W2 - W1 \times 100}{W}$$

3.2.5 Determination of Fibre

Fibre content was determined by fibrotron apparatus and method given by Ranganna (1995). Fiber content was determined by using following formula

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

3.2.6 Determination of Calcium

Calcium content was determined by method given by Ranganna (1995).
1 ml of 0.01N KMnO4 = 0.2004 mg calci

3.2.7 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)

3.3 Evaluation of Fermented batter

3.3.1 PH and Density of batter (g/cm3)

The pH of fermented batters was measured using PH meter. During the Idli Batter Preparation, the PH of the Batter Not More 5.9-4.8 is very important.If theph of the batter is High its make a puffed Structure which is not acceptable. The batter density was measured using a pycnometer

3.3.2 Acidity

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

3.3.3 Viscosity

Idli have viscosity in between 12000-14000 Poiseiulle (PI) for good appearance and Taste**.**

3.3.4 Sensory Analysis

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

3.2.7 Preparation of Idli Pre-Mix

"The idli batter was prepared with a 4:1 ratio of rice to black gram dhal. Both the rice and black gram dhal were washed, soaked for 5 hours, and then ground separately. Additionally, black cumin was roasted and powdered to be added to the batter. The two batters were then mixed to the required consistency, and 1% of the overall weight of salt was added. The batter was then allowed to ferment at room temperature for 6 hours. After fermentation was complete, the batter was transferred to a tray, spread evenly, and left to dry. The drying process started at 400-500°C for 3-4 hours."

Table 1. The proportion of Idli ingredients in black Cumin fortified Idli Pre-mix

Samples	**Ingredient (%)**			
	Rice	**Black cumin**	**Black gram**	**Salt**
R_0	80	-	20	01%
R_1	75	05	20	01%
R_2	70	10	20	01%
R_3	65	15	20	01%

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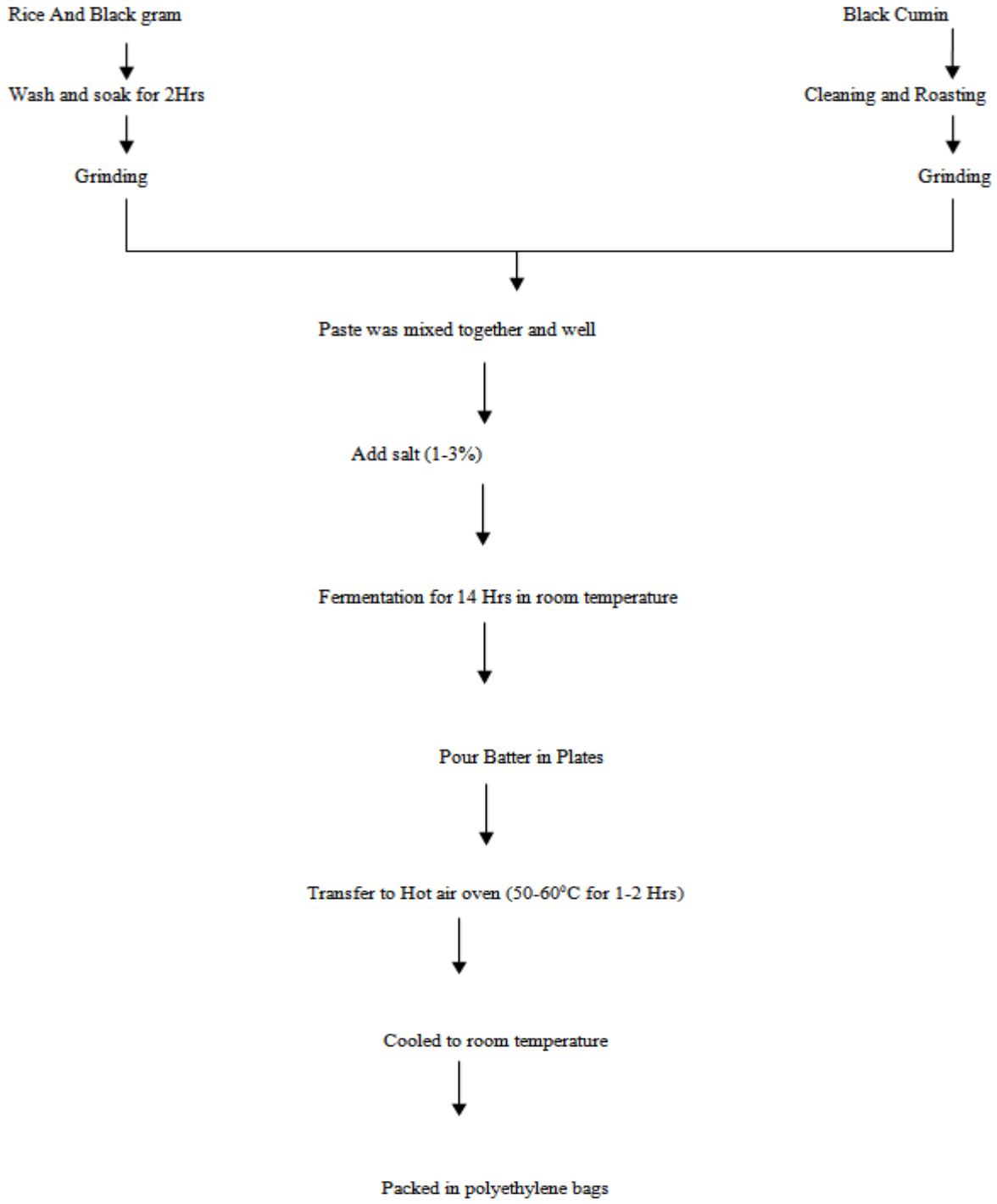
Fig.01 Graphical Representation Of Ingredient in Idli Premix

Method of preparation of Idli Pre mix

The dough was prepared and rolled in a proper shape and cut into round shape having thickness 6 mm with the help of cutter. These were baked at 175^{0}C for 15 min. **(**Khetarpaul et al., 2018)



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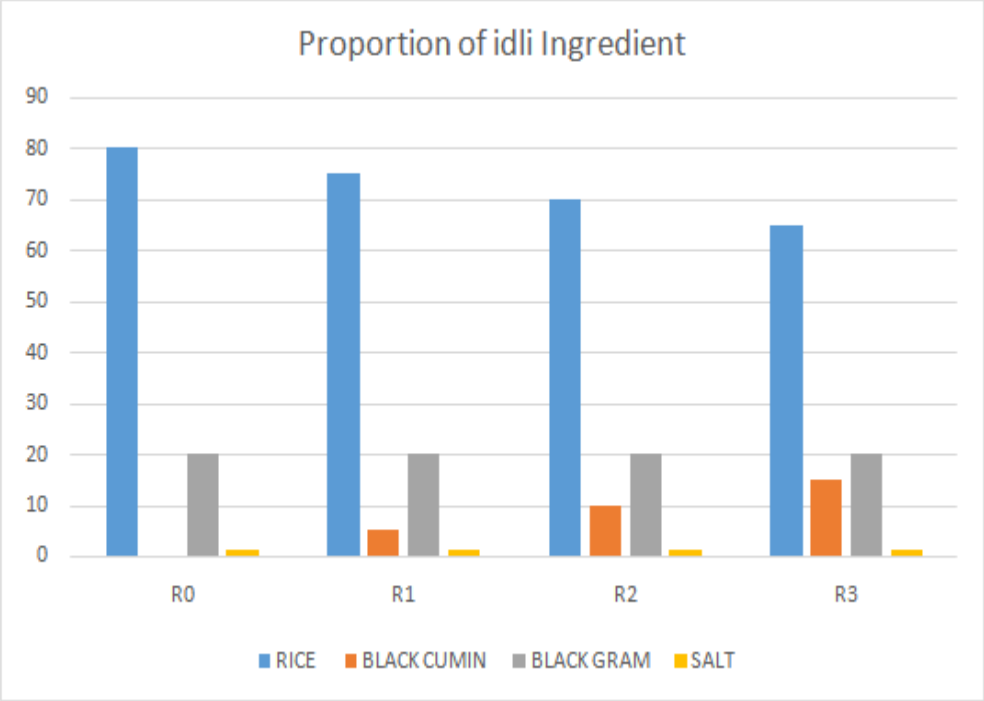

Fig.01 Idli Pre Mix Preparation

IV. RESULT AND DISCUSSION

4.0 Chemical Properties

Table 1. Chemical Parameters of Raw Material

Parameters (%)	Ingredients		
	Rice	Black Cumin	Black gram
Moisture	10.24	04.18	11.23
Protein	8.24	22.08	23.67
Crude Fat	2.84	41.31	01.68
Carbohydrates	76.61	17.00	57.23
Crude Fiber	0.64	08.24	01.08
Ash	1.13	04.30	03.16
Calcium (mg/100 g)	21.13	01.56	123.56

The highest value of moisture was found in black cumin (4.18 %) and the highest was in Rice (10.24 %). There is not much big difference in the moisture content of Brown Rice 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%) and black Cumin (22.08%)*. The lowest crude fat was observed in black gram (1.68%) whereas black cumin has more fat (41.31%). This may be due to the Natural structure of black cumin contributing to crude fat content. The amount of carbohydrates present in black gram, Black cumin, and brown rice is 57.23, 17, 76.6, and 76.61 percent respectively. The crude fiber, a digestive tract cleanser is highest in Black cumin (8.24%) making the product more nutritious. The fiber content of brown rice (0.64%) is more than Black gram (1.08%) indicating its importance in fullness index and satiety value. Black gram contains 1.08 percent fiber. Rice has the lowest ash value (1.13%) whereas, black cumin has the highest ash (4.30%). The highest calcium 123.56 mg/100 g is present in Black Gram followed by black Cumin (1.56 mg/100 g) and brown rice (21.13 mg/100 g).

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4.5.1 Organoleptic evaluation of black cumin seed Incorporation Idli Premix

Organoleptic characteristics of Idli Premix are pivotal in judging the suitability of product as consumer point of view. In order to study the effect of black cumin seed incorporation on sensorial quality characteristics, different random trials with wide range of Incorporation levels has been taken following the unorganized sensorial evaluation. It was observed that Idli Premix containing more than 5 % of black cumin seed powder Incorporation were not acceptable by panel members. Hence, for further optimization of black cumin seed Incorporation level in Idli Premix, organized trials were taken by incorporating different levels viz. 5, 10 and 15 % of black cumin seed Powder. The data pertaining to organoleptic quality evaluation of product is presented in Table-4.5.

Table 4.6: Organoleptic evaluation of Idli Premix Incorporated with black cumin seed

Sample Code	Color	Taste	Texture	Flavor	Appearance	Overall acceptability
Control	**8.5**	**8.4**	**8.8**	**7.9**	**8.3**	**8.38**
A	8.4	8.3	8.9	7.5	8.1	8.22
B	7.9	5.6	8.7	5.4	7.6	7.02
C	4.3	3.4	8.8	3.6	4.1	4.84
Mean	7.2750	6.4250	8.8000	6.1050	7.0275	7.1160
S.E.±	0.1572	0.1299	0.1392	0.0392	0.0337	0.0271
C.D. at 5%	0.4351	0.3596	0.3853	0.1087	0.0932	0.0751

* Each value represents the average of 10 determinations

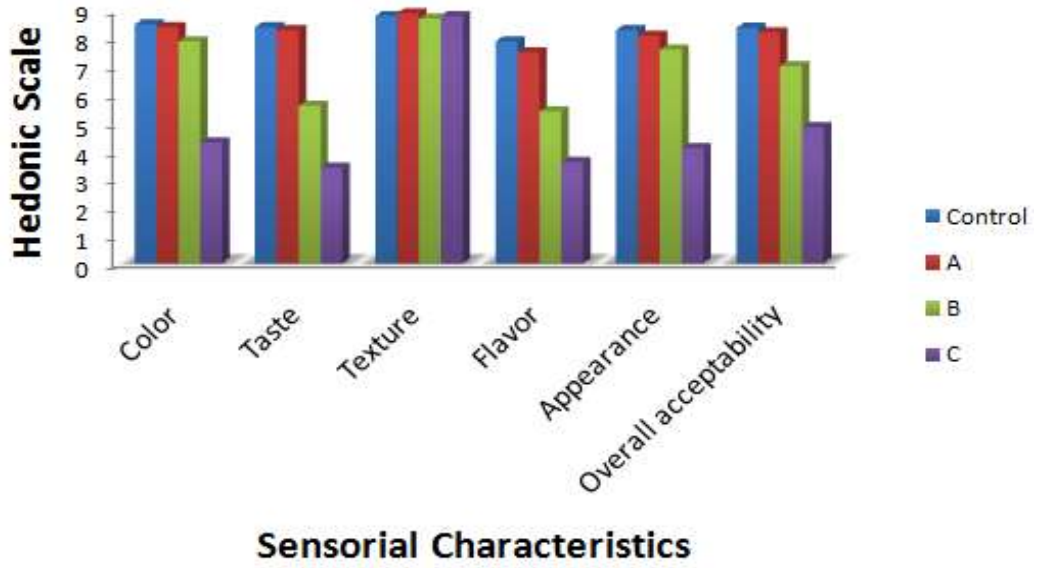

Fig. 4.1: Organoleptic evaluation of Idli Premix Incorporated with black cumin seed

4.5.2 Effect of black Cumin seed Incorporation on colour characteristics of Idli Premix

Color is considered as one of the important consumer quality judging parameters in the selection of food products. The attractive colour of product is a must-have in fast-moving consumer goods to appeal consumer for consumption. It could be observed from Table-4.5Idli Premix Incorporated with black cumin seed, the sensorial score for colour was found to decrease linearly with increase in level of Incorporation. Bright and light Idli Premix with increase in level of black cumin seed found to get contrast and dull has marked negative effect on colouring parameter of Idli Premix.

4.5.3 Effect of black cumin seed Incorporation on Taste of Idli Premix

With respect to taste characteristics of black cumin , 8.4 readings were observed for

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control sample while sample containing 5 % of black cumin seed scored 10 %. On consumer point of view, negligible change in taste was observed at the level of 5 % incorporation yet the taste was solely detectable as that of typical black cumin seed taste while more change was observed in sample containing 10 % of black cumin seeds,. However, when the level of Incorporated was further increase to 15 % there was drastic reduction in quality and the sample were not liked by the panel members. On the basis of observed results, it could be concluded that black cumin seed incorporation up to the level of 10 % is acceptable.

4.5.4 Effect of black cumin seed Incorporation on Textural characteristics of Idli-Premix

Textural characteristics of Idli play a pivotal role in judging its consumer acceptability. It could be stated that the textural characteristics of Idli are basically function of moisture content. It could be observed from Table-4.5 that in samples containing black cumin seed Powder, the textural properties are much more affected with increase in levels of black cumin seed.

4.5.5 Effect of black cumin seed Incorporation on Flavour profile of Idli

Flavour being a combination of taste, smell and mouth feel, has large number of factors it. Incorporation of black cumin seed powder resulted in negligible reduction of flavour characteristics up to the level of 5 %, while further increase in levels reduced the flavour scores to unacceptability. This may be due to typical flavour of black cumin, which could be prominently sensed in sample containing 10 and 15 % of black cumin seed. With the reference to incorporation levels of black cumin, it could be concluded that sample A and B is acceptable, amongst incorporated Idli.

4.5.6 Effect of black cumin fortification on Appearance characteristics of Idli Premix

The appearance properties of black cumin seed incorporated Idli were found to decrease with increase in concentration. The Idli were at the mark of unacceptability at higher concentrations. The incorporation of black cumin seed resulted in darkening of Idli which were principally responsible for reduction of appearance.

4.5.7 Effect of black cumin seed Incorporation on Overall acceptability of Idli Premix

Overall acceptability of product is depending on various factors including taste, colour, texture and appearance. The data pertaining to overall acceptability of product is described in Table-4.5. It could be observed from the table that overall acceptability of samples containing 5 % and 10 % of Black Cumin seed was acceptable.

It could be concluded on the basis of results that black cumin seed incorporation up to the level of 10 % acceptable on the basis of the overall acceptability score of Idli. While 15 % black cumin seed Incorporation Idli Premix was unacceptable.

4.5.8 Physical parameters of black cumin seed Incorporated Idli Premix

Physical properties of Idli Premix such as weight, diameter, thickness, spread factor and top grain development are indicative of the quality characteristics. The data pertaining physical parameters of black cumin seed Incorporated Idli prepared from Premix is presented in Table-4.6. It could be observed from the table that weight of Idli Premix remained more or less similar (though slightly lower) to that of control sample. Maintaining the constant weight of final product is essential to comply with the regulations and delivering uniform product to consumer. The weight of obtained product though lower to that of control, could be maintained to modifying initial weight of dough before baking.

4.5.9 Mineral Content (mg/100g)

Mineral	Idli Premix (mg/100g)	Idli Premix WithBlack Cumin (mg/100g)
Calcium (ca)	30	997
Iron (Fe)	2.1	68.3
Magnesium(Mg)	27	388
Phosphorus (P)	98	621
Zinc(Zn)	0.6	4.6
Potassium(K)	132	1788

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4.5.10 Textural Analysis of Idli.

Idli, a traditional South Indian breakfast dish, is known for its distinctive texture, which significantly influences its popularity and acceptance. The textural qualities of idli are shaped by various factors, including the ingredients, fermentation process, and steaming conditions. Here's a detailed analysis:

Softness: Idlis are characteristically soft, which makes them easy to chew and digest. This softness is largely a result of the fermentation process involving a mixture of rice (Oryzasativa) and black gram dal (Phaseolus mungo). The lactic acid bacteria produced during fermentation help break down starches and proteins, resulting in a soft texture.

Sponginess: The spongy texture of idli comes from the carbon dioxide produced during fermentation. This gas is trapped in the batter, creating a porous structure. The ratio of rice to dal and the duration of fermentation are crucial in determining the sponginess. Idlis have a high moisture content, contributing to their softness and palatability. The steaming process helps retain moisture within the idlis, and achieving the right moisture level depends on proper fermentation and steaming time.

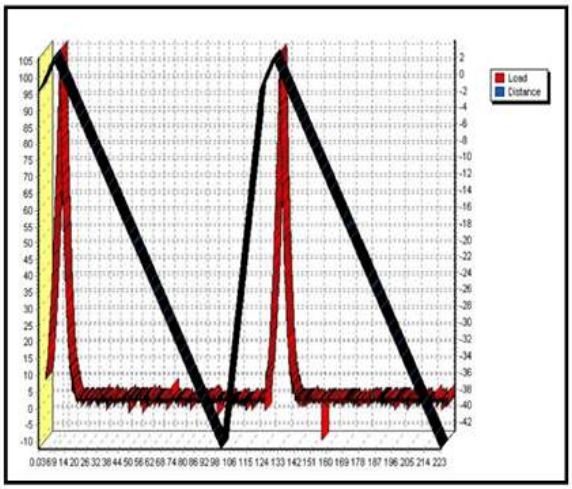
Elasticity:A well-prepared idli exhibits a certain degree of elasticity, allowing it to bounce back when lightly pressed. This elasticity is due to the gelatinization of starches during steaming and the protein network formed by the dal.

Mouthfeel: The mouthfeel of idli should be smooth and not grainy. Achieving this smooth texture requires grinding the rice and dal into a fine batter. The batter should have a consistency that allows for a smooth and homogeneous mixture.

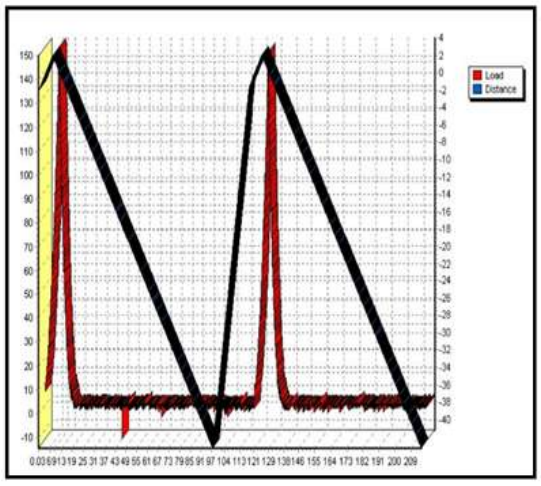
Cohesiveness: Idlis should hold together well without crumbling. Cohesiveness is influenced by the quality of the batter and the fermentation process. Both over-fermentation and under-fermentation can negatively affect cohesiveness.

Firmness: Althoughidlis are soft, they should have a slight firmness that helps maintain their shape and structure. This balance between softness and firmness is crucial for the perfect idli, and firmness is often assessed by the resistance offered by the idli when cut or bitten into.

Resilience: Resilience refers to the idli's ability to recover its shape after deformation. A resilient idli will bounce back after being pressed, indicating proper fermentation and steaming.



Graph 4.2 Graphical Representation of Texture of T1.



Graph 4.3 Graphical Representation Of Texture of T2.

4.7Physical characteristics of the prepared Idli Premix

Parameters	T1	T2
Swelling ratio (%)	1.70±0.54	1.90±0.5

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Physiological Parameters	**Dispersion Test (minutes)**	7.96±0.46	10.34±0.09
	Syneresis Test (%)	0	0
	Average weight (g)	3	2.5
Dimension	**Length (cm)**	1.50	1.50
	Width (cm)	1.50	1.50
	Thickness (cm)	1.0	1.0
Texture	**Hardness (g)**	106.00	150.00
	Adhesiveness (mJ)	0.00	0.00
	Cohesiveness	0.90	0.88
	Gumminess (g)	95.00	132.00
	Springiness (mm)	3.90	3.98
	Chewiness (mJ)	2.80	5.10

* Each value is an average of three determinations.

4.5.11 -Techno-economic feasibility of Idli Premix

Techno-economic feasibility of Idli Premix was evaluated based on the basis of

1. **Operating Costs:** Ongoing expenses such as utilities, maintenance, and other operational expenditures.
2. **Raw Material Costs:** The cost of acquiring and processing raw materials needed for production.
3. **Production Costs:** Expenses associated with the actual manufacturing process, encompassing labor, energy, and other inputs.
4. **Processing Costs:** Expenses linked to transforming raw materials into finished products, which may involve various processing steps.
5. **Packaging Costs:** Expenses related to packaging materials, labeling, and packaging operations.

4.5.12Theoretical energy of Idli Premix incorporated With Black Cumin Seed (Measurement)

The energy value is determined by using the values of crude protein, crude fat and total carbohydrate content in the sample, taking into account that 1 g of protein produces 4 Kcal energy, 1 g of fat produces 9 Kcal energy, and 1 g of carbohydrate produces 4 Kcal energy. The total energy value is obtained by adding the above three energy values, and these three energy values give the energy value per 100 g of sample.

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V. CONCLUSION

In the study, Rice, black gram and black cumin is used to prepare idli premix by different ratios of black cumin seed at levels of 05%, 10%, and 15%. The sample with 05% black cumin was selected for further fortification based on sensory analysis. The study data indicates that incorporating black cumin into idli pre-mix increases its fiber and calcium content. Although texture showed that the fortified idli premix powder had a slightly harder texture after cooking, it was still deemed acceptable in sensory evaluation.

Different types of formulations were used to prepare the Idli Premix by incorporating different levels of black cumin seeds Powder. Experimental sample containing 10 % of black cumin seed were found to be the best which was resulted in organoleptic score. Higher percentage of black cumin seed drastically decreased taste and flavour of Idli.

Physical properties of Idli Premix were studied where data indicated that there was no significant change in values of weight, diameter and thickness of Idliwhere as slight deviation was observed in spread factor and top grain development of all treated samples.

The Idli Premix adjudged as a best were subjected to proximate composition of black cumin Incorporated Idli Premix. Result revealed that there was difference in Black Cumin Seed content of samples. The Minerals content was higher as compare to control.

Efforts were also made to study the effect of storage on physical and sensorial parameters of Idli Incorporation with fixed Black cumin at interval of 15, 30, 45, 60, 75 and 90 days. In the present investigation, storage of Idli Premix for 90 days produced non-significant changes in all sensory quality attributes.

In present investigation studied the antibacterial activity of petroleum ether, acetone extracts and steam distillation oil of N. sativa seeds were tested against pathogenic bacteria. Among the test bacteria Staphylococcus aureus was shown greater zone of inhibition against all extract of N. sativa oil. While Pseudomonas aeruginosa and Escherichia coli were show moderate zone of inhibition.

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