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Development and quality evaluation of maize *Idli*

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Abstract
A study was conducted to develop and evaluate fermented *idli* from maize. Different levels of maize semolina (600 microns) were mixed with black gram dhal (2:1, 3:1 and 4:1 ratios) and evaluated for acceptability using subjective and objective methods by taking rice *idli* in 3:1ratio (rice: black gram dhal) as control. Proximate composition, anti-nutrients, protein and starch digestibility of the best accepted ratio was evaluated at different stages of preparation (raw ingredients-R, after soaking-S, after fermenting-F and after steam cooking-C) by standard procedures. Taste, texture and overall acceptability scores were superior for 3:1 ratio of maize and black gram dhal. Low chewiness value noticed in 3:1 ratio indicating softer product. Increase in protein and mineral contents, decrease in crude fiber and carbohydrate contents upon fermentation and cooking was noticed with concomitant reduction of phytic acid, polyphenol and tannin contents. Protein and starch digestibility of the *idli* was found to improve during stages of *idli* preparation.

Keywords: Chroma, chewiness, digestibility, polyphenols

1. Introduction
Cereal grains are known to be the staple food for majority of the population all over the world and are considered to be one of the most important sources of carbohydrates, dietary proteins, some of the vitamins, minerals and fiber. However, the nutritional quality of cereals and the sensorial properties of their products are sometimes said to be inferior or poor in comparison with milk and milk products. The reasons behind this are may be the lower protein content, the deficiency of certain essential amino acids (lysine), low starch availability, presence of varying amounts of anti-nutrients (phytic acid, tannins and polyphenols) and the coarse nature of the grains. The major cereal produced and consumed in India includes rice wheat, maize and millets. In India, maize is next to rice and wheat in terms of acreage and ranks second in terms of total production and productivity Murdia *et al.*, (2016) [1]. Even though maize grain contains good amount of carbohydrates, proteins, fat and some of the important vitamins and minerals, its nutritional quality is low due to the lack of lysine and tryptophan. However which can be overcome by combining with good quality pulses. In spite of this, most of the maize being produced in the developing countries is for human consumption while that in the developed world it is mainly for industrial use and animal feed FAO, (1992) [2]. Industrially maize has various end uses such as poultry feed (51%), human food (23%), animal feed (12%), starch (12%) and 1% each for brewery and seed Parihar *et al*., (2011) [3]. India has a very low ratio of maize going towards direct consumption as most of the maize being utilized for production of feed, starch and ethanol.

A number of methods including combining with good quality pulses have been employed in order to ameliorate the nutritional qualities of cereals. A part from this, several traditional processing techniques such as cooking, sprouting, milling and fermentation have been put into practice to improve the nutritional quality of cereals and one such commonly employed traditionally followed method is fermentation. In general, natural fermentation of cereals leads to decrease in the level of carbohydrates as well as some non-digestible poly and oligosaccharides. Certain amino acids may be synthesized and the availability of B group vitamins may be improved. Fermentation also provides optimum pH conditions for enzymatic degradation of phytate which is present in cereals in the form of complexes with polyvalent cations such as iron, zinc, calcium, magnesium and proteins. Such reduction in phytate may increase the amount of soluble iron, zinc and calcium several folds Chavan and Kadam, (1989) [4].

In the recent past, diversified foods from different crops are gaining popularity owing to its complementary health benefits. So also the traditional food processing techniques such as soaking, malting roasting and fermentation yields a product with good nutritional quality at lower cost. Lactic acid fermentation of cereals is a long-established processing method being used in Asia, Africa and other countries and these fermented foods which are strongly linked to our tradition and culture have been prepared and consumed since age old days and are good in terms of palatability, digestibility, nutritive value as well as bioavailability of nutrients. Fermented foods have many beneficial products metabolized by bacteria and fungi including biomass proteins, amino acids, carbohydrates, vitamins, minerals, flavor and aroma compounds among others (Annan *et al.*, 2003) [5].

In this line, fermented foods of cereal and pulse combination constitute an important part of human diet in developing countries such as India and number of fermented foods such

as *dhokla* Sekar and Mariappan, (2007) [6], *Koozhu* (Khanji), fermented rice (Pazhaiya soru), *dosa*, *ambali*, *nan*, *siddhu* and *idli*, (Ravi *et al.*, 2010) [7] are already popular. *Idli* is fermented, thick suspension made of a blend of rice (*Oryza sativum*) and dehulled black gram (*Phaseolus mungo*) is used as breakfast item in Southeast Asian countries. Among them, *idli* and *dosa* are very popular in India and Sri Lanka (Blandino *et al.*, 2003) [8]. With the growing demands for breakfast foods, *idlis* are being consumed on a large scale in some Indian institutions such as army, railways, industrial canteens, etc. The preparation method and nutritional advantages of *idli* from rice and other millets is a long established research outcome of many researchers (Nazni and Shalini. 2010 [9]; Ghosh and Chattopadhyay, 2011 [10], Balasubramanian *et al.*, 2015) [11]. However, fermented *idli* from non traditional crops such as maize are yet to become popular among larger mass. A huge potential exists for these products as they provide variety to the consumers along with improved nutritional quality due to fermentation at lower cost. Hence, the present study was undertaken to evaluate the feasibility of using maize semolina for *idli* preparation and evaluate its quality in comparison with rice *idli*.

2 Material and methods

2.1 Standardization process of maize *idli*

Grains of maize hybrid (NAH-2049) were procured from All India Coordinated Research Project (AICRP) on maize, Zonal Agricultural Research Station, V.C Farm and were subjected to lime treatment. Lime treatment involves the addition of one per cent lime (calcium hydroxide) solution (w/v 1:2) and the mixture was heated at 80ºC for 30 min and allowed to stand overnight. The following day cooking liquor was decanted and the grains were washed three to four times to remove the excess lime and any impurities in the grain (Palacios Fonseca *et al.*, 2009) [12]. The grains were sun dried till the moisture percentage reaches to around 9-10 percent. The grains were dry milled in a mini SS dry grinder mill, passed through 25 BS sieve to get maize semolina of 600 microns. Other ingredients such as black gram dhal, rice and salt were procured in a single lot and refrigerated until further use. Maize semolina and black gram dhal in the ratio of 2:1, 3:1 and 4:1 by weight were taken for standardization purpose. Black gram dhal was ground to fine consistency and at the end of grinding; maize semolina was added and ground for two min, water was added as and when necessary. This forms a batter for the preparation of fermented *idli.* Two per cent salt (NaCl) to the weight of the batter was added and allowed to ferment for a period of 14 h at room temperature. The fermented batter was mixed thoroughly to expel the gas released due to production of carbon-dioxide. The batter was dispensed into *idli* mould and steam cooked for 15 min. Control *idli* was prepared by fermenting rice semolina (600 microns) and black gram dhal in the ratio of 3:1 for 14 h and steaming for 15 min (Ghosh and Chattopadhyay, 2011).

2.2 Objective method of evaluation

Maize *idli* in different ratios (2:1, 3:1 and 4:1) were subjected to objective method of evaluation along with control (rice *idli* in 3:1 ratio). Under objective method of analysis, color of the product was assessed using Spectrophotometer (CM-5, Konica minolta) in terms of Hunter parameters as per Olajide *et al*., (2010) [13], where in L*denotes lightness (ranging from 0-100 indicating black to white) a*denotes the colour shift from green towards red (+a indicates redness and –a indicates greenness) and b* represents the colour shift from yellow to blue (+b: yellowness and –b: blueness).The texture *of idli* was analyzed using p/ 75 mm compression platen in texture analyzer (TA-HDi Texture analyzer – Stable micro system) using an inch cubic mould. The cut piece was placed on the platform and test speed was set to 5mm /sec and the probe compressed at a distance of 10 mm of the cut piece to get texture profile analysis (TPA) of the *idli.* Based on the force deformation curves, other textural parameters like adhesiveness, springiness, cohesiveness and chewiness were calculated by in- built software.

2.3 Subjective method of evaluation

Maize *idli* in three different ratios were evaluated by a panel of semi trained judges (n=21) in order to select the best acceptable ratio. The panel members for sensory evaluation consisted of staff of ZARS, V.C. Farm, Mandya. Panelists were provided with coded samples along with glass of water and instructed to rinse and swallow water between the samples. Panelists were given written instructions and asked to evaluate the products for acceptability based on its appearance, color, taste, texture and overall acceptability on nine-point scale, where in 9= dislike extremely, 8= like very much, 7= like moderately, 6= like slightly, 5= neither like nor dislike, 4= dislike slightly, 3= dislike moderately, 2= dislike very much, 1= dislike extremely.

2.4 Nutritional composition

The best accepted ratio from the subjective and objective evaluation was taken for analysis of nutritional parameters at four stages of preparation viz., raw ingredients in 3:1 ratio (R), Soaked ingredients (S), fermented ingredients (F) and cooked samples (C). Raw ingredients in 3:1 ratio, soaked in known quantity of water for six hrs, ground in a mixer grinder which served as soaked ingredients (S), the ground batter was allowed to ferment for 14 hrs and dried in a hot air oven at 50^0 C for 16 hrs as per Sokrab *et al.*, (2012) [14]. Dried samples of fermented batter were milled to fine powder and passed through 60 BS sieve, which served as sample after fermentation (F). Another set of fermented batter was steam cooked for 15 min and dried in a hot air oven at 50ºC for 12 hrs and above procedure was followed for sample preparation (after steam cooking- C).

The micro kjeldhal method was employed to determine the total nitrogen (Gerhardt- Vapodust) and the crude protein content (N x 6.25) Crude fat (Socsplus - SCS 06AS) was estimated by extraction with petroleum ether (60–80 °C) while, Crude fiber (Fibraplus-FES04) and ash contents were determined as per AOAC (2000^{15}). Carbohydrate (by difference method) and energy was computed by taking protein (4 kcal/g), fat (9 kcal/g) and carbohydrate (4 kcal /g) values.

Minerals of the *idli* samples at four stages of preparation were determined by dry ashing method as described by (Chapman and Pratt 1982) [16]. Calcium was determined by titration method, while Phosphorus was determined

spectrophotometerically by using molybdovanadate method. All other minerals were determined by atomic absorption spectrophotometer (Perkin– Elmer 2380, Norwalk, Connecticut, USA).

2.5 Analysis of major anti nutrients

In four stages of *idli* preparation (R S, F, C) the changes in anti nutritional factors (Phytic acid, polyphenol and tannin) were assessed.

1. **Estimation of phytic acid:** Phytic acid phosphorus was estimated by wade reagent method as per (Gao *et al.*, 2007) [17] with minor modifications and the concentration of phytic acid was obtained by multiplying the phytic acid phosphorus with the conversion factor 3.55. Ground sample of 0.5g (5 mm mesh) was taken and transferred into 30 ml okridge tubes. To the sample, 10 ml of 2.4 percent HCl was added and shaken on gyratory shaker at room temperature for 16 hours at 220 rpm. Tubes were centrifuged at 1000 rpm at 10°C for 20 min. Another fresh tube with one g of NaCl was taken and collected the supernatant in those fresh tubes and shaken for 20 min at the rate of 350 rpm in room temperature. Mixture was allowed to settle at 4°C for one hour followed by centrifuging at 1000 rpm at 10°C for 20 min. collected the treated supernatant and used for color development with Wade reagent. One ml of supernatant was added to 24 ml of distilled de ionized water, out of which 3 ml of supernatant was diluted with water followed by addition of one ml of Wade reagent and the mixture was vortexed for 5-10 sec. Centrifuged the contents at 1000 rpm at 10°C for 10 min and absorbance was measured at 500 nm. Results were expressed as percentage of dry weight (mg/100g). Phytate-phosphorus was converted to phytate by multiplying with a factor 3.55.
2. **Estimation of Polyphenol content:** Total poly phenols were determined according to the Prussian blue spectrophotometric method (Price and Butler 1977) [18] with minor modification using gallic acid standard (0.094 gallic acid monohydrate)**.** Sixty ground per 50 ml methanol samples were shaken manually for one min in three ml methanol. The mixture was filtered and the filtrate was mixed with 50 ml of distilled water and an analyzed within one hour. About three ml of 0.1 M $FeCl_3$ in 0.1 M HCl was added to one ml filtrate followed by timed addition of three ml freshly prepared $K_3Fe(CN)_6$. The absorbance was monitored on a spectrophotometer (PyeUnicam SP6-550UV, London, UK) at 750 nm. After 10 min from the addition of three ml of 0.1 M $FeCl_3$ and three ml of 0.008 M $K_3Fe(CN)_6$. Standardization was done using 0.01M gallic acid. A standard curve was obtained and the results were expressed as gallic acid equivalents (GAE); that is, the amount of gallic acid (mg/100 g).
3. **Estimation of tannins:** Tannins were estimated calorimetrically based on the measurement of blue colour formed by the reduction of phosphotungstomolybdic acid in alkali solution. Zero to ten ml aliquots of the standard tannic acid solution were taken into 100 ml volumetric flask containing 75 ml of water and added with three ml of Folin denis reagent and ten ml sodium carbonate solution into each of the volumetric flasks and volume was made up to 100 ml with distilled water. Solution was mixed well and measured the colour after 30 min at 760nm against experimental blank. For sample preparation, five gram of sample was extracted with 85 ml of methanol containing one per cent HCl for 30 min with occasional shaking. The contents were filtered using whatman No. 1 filter paper. One ml of extract was transferred to 100 ml volumetric flask to which five ml of Folin-denis reagent and 10 ml of sodium carbonate were added and mixed thoroughly followed by diluting the contents to 100ml using distilled water and allowed to stand for 30 min and absorbance was measured at 760nm. The tannin content of the samples was calculated as tannic acid equivalents from the standard graph (Ranganna 2000) [19].

$$Tannin\ (\%) = \frac{\text{mg of tannic acid X dilution X 100}}{\text{ml of sample taken for colour development X weight of the sample}}$$

2.6 *In-vitro* protein digestibility (IVPD) and *In vitro* starch digestibility (IVSD)

IVPD of defatted samples was estimated according to the method as described by Lorri and Svanberg (1993) [20] and Mouliswar *et al.*, (1993) [21] respectively. For estimation of protein digestibility, One gram of sample was mixed with 35 ml of 0.1 M citrate-phosphate buffer (pH 2.0) containing 42.5mg of pepsin (Sigma, 232-629-3) and incubated at 37° C for 2 h. After centrifugation at 5000 × *g* at 30° C for 15 min; the residue was held in 10 ml of 0.1 M citrate phosphate buffer (pH 2.0) and centrifuged again at 2500 × *g* at 30°C for 15 min. The residue was resuspended in 35 ml of 0.1 M phosphate buffer (pH 8.0) containing 42.5 mg of pancreatic (Sigma, 8049-47-6) and incubated at 37° C for 1 h. The mixture was centrifuged at 2500 × *g* at 30° C for 15 min; the supernatant was discarded and the residue was centrifuged twice with 10 ml of 0.1 M phosphate buffer (pH 7.0). The residue was filtered through what man No.1 filter paper and dried at 80°C for 30 min and analyzed for total nitrogen content by following kjeldahl method using the formula

Per cent protein digestibility = [(total nitrogen - undigested nitrogen) / total nitrogen] ×100

For estimation of *In vitro* starch digestibility (IVSD), One gram of sample was suspended in 100 ml of distilled water and cooked in a boiling water bath for 15 min. To 50 ml of this slurry,30 ml of 0.2 M citrate-phosphate buffer (pH 2.0) containing 10 mg of pepsin was added followed by incubation at 37°C for 2 h. After neutralization with 0.2 M sodium hydroxide, the volume was made up to 100 ml with distilled water. Ten milliliters of this mixture was incubated with 5 ml of 0.5M phosphate buffer (pH 8.0) containing 15 mg of pancreatin (Sigma, 9032-080-0) and 15 mg of amyl glucosidase (Sigma, 9032-080-0) at 37°C for 2 h. One milliliter aliquots were drawn at the end of 2 h and assayed for reducing sugars released with glucose as standard according to Somogyi method

Per cent starch digestibility = (mg glucose liberated/mg starch in sample) × 100

2.7 Statistical analysis
Analysis of variance (ANOVA) was applied to test the significant difference between the samples for colour and textural profile analysis. For nutrient, anti-nutrient and digestibility studies, paired't' test was used to compare the significant differences between the samples at different stages of preparation. The data was analyzed using SPSS (statistical package for the social sciences) 16.0 software and the significant difference was defined at $p<0.05$.

3 Results and Discussion:
3.1 Standardization of *idli*
Conventionally 3:1 ratio of rice semolina and black gram dhal is used for the preparation of *idli* (Balasubramanian and Viswanathan, 2007) [22]. In order to standardize maize *idli*, one ratio less (2:1) and one ratio more (4:1) than the standard *idli* (3:1) were prepared and evaluated for their acceptability based on subjective and objective method of evaluation

3.2 Objective method of evaluation
The color attributes of *idli* is depicted in Table 1. Lightness in the *idli* plays an important role in consumer perception. The lightness value L* was significantly more for control (78.42) followed by 2:1, 3:1 and 4:1 ratios of maize and dhal combinations indicating that the rice *idli* was naturally more lighter in colour compared to maize *idli.* The a* value which indicated redness, was least for rice *idli* (0.95) and significantly high value was observed with maize *idli* in the ratio of 4:1 (9.55), followed by 2:1 and 3:1. The b* value, which indicates yellowness was significantly more for maize *idli* in the ratio of 4:1(38.74), followed by 3:1 (37.03) and 2:1 (35.83) respectively. It indicated that the *idli*s prepared with 4:1 ratio were found to be dark yellow in colour, compared to rest of the combinations. Colours can be differentiated by the brilliance or strength. The chroma values are closer to b* values (Table 1).

Table 1: Color attributes of maize *idli*

Variations	L*	a*	b*	Chroma	Hue angle (°)
2:1	75.55	7.94	35.83	36.72	77.52
3:1	74.29	8.16	37.03	37.92	77.57
4:1	72.37	9.55	38.74	39.90	76.14
3:1 (Control)	78.42	0.95	12.43	12.47	85.62
F Value	*	*	*	*	*
S. Em±	0.02	0.01	0.01	0.01	0.03
CD at 5%	0.06	0.04	0.04	0.05	0.08

Note: 2:1, 3:1 & 4:1 are maize semolina: black gram dhal, control (3:1) is rice: black gram dhal. L* brightness, a* redness, b* yellowness. C*(Chroma) = $\sqrt{a^2+b^2}$, H*= $\tan^{-1}\left(\frac{b}{a}\right)$. Where 'a' +ve = indicates redness, 'a –ve indicates greenness

The intensity of chroma is low for rice *idli* and high for maize *idli*, indicating that the differences in the ingredients used for *idli* making which had an impact on the intensity of chroma. The hue angle corresponds to whether the object is red, orange, yellow, green, blue or violet. The values for hue angle were positive in all our ratios with a significant difference observed between control and different ratios of maize, indicating that the product deviates towards redness not towards greenness.

Decrease in lightness (L*), increase in redness (a*) and yellowness (b*) was observed with maize incorporated *idlis* in this study. Even the study conducted by (Balasubramanian *et al.,* 2015) indicated loss of brightness (L*) decrease in yellowness (b*) for millet *idli*. However in our study increase in redness and yellowness in maize combinations was obvious due to incorporation of maize semolina in different ratios. The acceptable range of L* (> 56.98) and b* (<7.13) for *idli* was quoted by (Balasubramanian *et al.*, 2015). In our study L* was above this value in all the combinations tested, however a* and b* values vary based on the type of ingredients and their level of incorporation in *idli* making. This instrumental colour analysis of *idli i*n 3:1 ratio of rice: dhal with 14 hr fermentation time was in the range reported by Durgadevi and Shetty (2012) [23] for L*, b* and chroma.

The textural profile of *idli* with different ratios of maize semolina is depicted in Table 2. The hardness of *idli* indicated by maximum force required to compress the *idli*, and is usually represented by the first peak in the graph. The hardness of *idli* was found to be significantly differed among different ratios of maize and also with control. The hardness of *idli* was significantly more for maize *idli* in the ratio of 4:1(26.18 N) and was least for control *idli* in 3:1 ratio (20.11 N).Among the maize *idli* hardness was significantly less for 3:1 ratio (22.24). This variation in force was due to variation in the ratio of ingredients used. Higher the force, harder will be the *idli,* hence *idli* in 3:1 ratio of maize as well as control require less force compared to rest of the ratios indicated that they were less hard compared to rest of the combinations. The hardness of *idli* in (Durgadevi and Shetty 2012) study, varied between 20.58 N to 44.19 N depending on variations in ingredients and fermentation time. In our study, minimum hardness value of 20.11N was observed in 3:1 ratio of rice: black gram dhal, followed by 3:1, 2:1 and 4:1 ratio of maize: black gram dhal. Lower the hardness, softer will be the product, hence low value for hardness was noticed in 3:1 ratio of rice as well as maize *idli.* The results indicated that the ratio of cereal and pulse used for making *idli* plays a significant role for the hardness.

Table 2: Textural profile of maize *idli* with different levels of maize semolina incorporation

Variations	Hardness (N)	Cohesiveness#	Springiness#	Chewiness#	Adhesiveness (Ns)
2:1	25.40	0.40	0.993	10.08	-0.004
3:1	22.24	0.26	0.990	8.78	-0.006
4:1	26.18	0.33	0.992	9.37	-0.01
3:1 (Control)	20.11	0.13	0.993	11.11	-0.007
F Value	*	*	*	*	*
S. Em±	3.78	0.02	0.05	0.71	0.72
CD at 5%	12.33	0.06	0.16	2.31	2.35

Note: 2:1, 3:1 & 4:1 are maize suji: black gram dhal, control (3:1) is rice: black gram dhal. N-Newtons, Ns- Newton seconds. #-parameters were unit less. Values are means ± standard deviations. (p=0.05) (n=3).

Cohesiveness is defined as the ratio of positive force area

during second compression to that of first compression. The cohesiveness value was minimum (0.13) for 3:1 ratio (control) and maximum for 2:1 maize *idli* (0.40) at 14 h fermentation time. The springiness value indicated the soft spongy texture of the cooked *idli*, which in turn depends on the quantity of black gram dhal used for preparation. The springiness values for control (0.993) and 2:1 ratio of maize and black gram dhal (0.993) were same, but in other ratios also the springiness values marginally varied even though statistically significant indicating that the softness of *idli* was not significantly differed. Soft spongy texture observed in the leavened steamed *idli* made out of black gram dhal was due to presence of two components, namely surface active protein (globulin) and a polysaccharide (arabinogalactan) in black gram (Susheelamma and Rao, 1980) [24] The specialty of black gram in *idli* preparation is due to the mucilaginous property which helps in the retention of carbon-dioxide evolved during fermentation (Nazni and Shalini 2010). Chewiness is defined as the product of hardness X cohesiveness X springiness and is therefore influenced by change of any one of these parameters. Lower the chewiness, softer will be the *idli.* The low chewiness value was noticed in maize *idli* in the ratio of 3:1 (8.78) and maximum chewiness was noticed in rice *idli* in the same ratio (11.11). The adhesiveness of the product varied between -0.01 to -0.007 Ns. If the product is sticky, the adhesiveness will be more. The high value for adhesiveness was observed in 4:1 ratio of maize *idli*, and low in 2:1 and 3:1 ratio of maize *idli.* These differences in adhesiveness were observed due to quality of ingredients as well as ratio of rice or maize and black gram dhal. Since the batter was coarsely ground and fermented under constant time, there was not much variations observed with adhesiveness indicating that the *idlis* in all the ratios were not sticky.

3.3 Subjective method of evaluation

The sensory acceptability of maize *idli* in terms of colour (8.75) taste (8.60) texture (8.80) flavor (8.45) and overall acceptability (8.30) of maize *idli* was found to be superior for 3:1 ratio compared to other ratios tested (data not shown).

3.4 Nutritional composition of *idli* at different stages of preparation

The change in the proximate composition of maize and rice *idli* on moisture free basis at different stages of preparation is depicted in Table 3.

Protein content of maize as well as rice *idli* increased marginally from raw (12.20 to 12.60% in maize and 11.07 to 11.63% in case of rice) to fermented stage and decreased slightly after cooking. However the changes in protein content of rice *idli* during stages of preparation were not significant. Works of Odunfa (1985) [25] and Ogunshe *et al*., (2007) [26] also showed increase in protein content during fermentation. However, a contradictory report on protein content in fermented pearl millet lohoh was reported by Osman, (2011) [27]. The fat content of samples decreased in both the samples from raw to cooked stage (Table 3) in both the samples indicating that both the samples behave in similar pattern with respect to fat content. Osman (2011) reported no significant change in the fat content during preparation of pearl millet lohoh bread. Even Kazanas and Fields (1981) [28] did not observe any significant change in crude fat content of sorghum after natural lactic acid fermentation for four days. Meager amount of data is available on changes of lipid content during fermentation compared to carbohydrates and proteins. This may be due to the fact that cereals are generally low in lipid content.

Table 3: Proximate composition of maize and rice (control) *idli* at different stages of preparation (moisture free basis)

Stages of *idli* Preparation	Protein (%)		Fat (%)		Ash (%)		Crude fiber (%)		CHO (g)		Energy (Kcal)	
	Maize	Rice	Maize	Rice	Maize	Rice	Maize	Rice	Maize	Rice	Maize	Rice
Raw	12.20	11.07	1.91	0.95	2.42	2.44	1.37	1.21	75.91	76.71	366.93	355.28
Soaked	13.91	11.59	1.80	0.81	2.58	2.87	1.24	1.13	73.74	76.33	366.06	355.75
Fermented	12.60	11.63	1.72	0.48	2.88	3.26	1.09	1.02	74.17	73.64	363.32	348.38
Cooked	12.45	11.84	1.61	0.45	1.62	3.18	0.93	0.94	72.43	70.90	356.71	339.50
F value	*	NS	*	*	*	*	*	*	*	*	*	*
S Em±	0.02	0.19	0.07	0.03	0.04	0.04	0.04	0.04	0.11	0.18	0.23	0.36
CD at 5%	0.09	-	0.23	0.10	0.14	0.13	0.14	0.12	0.37	0.57	0.76	1.18
t value												
Raw	9.89*		117.37*		6.65*		1.40		41.59*		92.35*	
Soaked	31.10*		7.75*		13.08*		5.67*		15.36*		12.79*	
Fermented	32.70*		15.64*		144.06*		0.78		110.68*		1.53	
Cooked	48.23*		871.69*		2.70		3.50		14.94*		69.92*	

*Significant at $p \leq 0.05$ NS: Non significant Raw, soaked, fermented, cooked are powdered samples of 3:1 ratio

Salt to the batter might have contributed to ash content increase after fermentation. The increase in ash content in fermented dhoklu was observed by Marina *et al*., (2013) [29] and Osman (2011) for pearl millet during 16 hr fermentation period which was due to reduction of anti-nutrient content may increased the ash per se of the product.

Changes in crude fiber content during various stages of preparation (Table.3) indicated that crude fiber content decreased significantly in both the samples from raw to cooked stage. However, the difference between the samples of maize and rice was found to be non-significant (except soaked samples) at different stages of preparation which is due to increase in the micro flora population which uses fiber in their metabolism. The carbohydrate content of both the samples decreased significantly from raw to cooked stage (75.91 to 72.43 % in maize and 76.71 to 70.90% in rice) and was significant between the samples as well as between the stages of preparation. Carbohydrate content of the fermented

products decreased due to increased micro flora which utilizes carbohydrate for their metabolic activities. The similar kind of trend was has been reported for sorghum by many researchers (Abedelseed *et al.,* 2011 and Osman, 2011) [30].

The perusal of Fig.1 reveals the mineral composition of *idli* in different stages of preparation. The iron, zinc, calcium magnesium,, phosphorus, sodium, and potassium contents of maize and rice *idli* increased significantly from raw to fermented stage however, marginal differences were noticed in mineral contents of cooked samples (Fig 1). It is inferred that increased minerals in 14 h fermented maize and control samples in our study is in agreement with Sokrab *et al*., (2012) for iron, sodium, potassium, magnesium, calcium and phosphorus contents. The increment in both major and trace minerals of corn genotypes was due to the reduction of anti nutrients (phytate and polyphenols) as a result of fermentation. Even the results of Eltayeb *et al.,* (2008) [31] and Abdelseed *et al.,* (2011) demonstrated an increase in iron contents of millets and sorghum after fermentation. According to FAO (1992) [32], the corn germ is relatively rich in minerals, (phosphorous, calcium, sodium, potassium) with an average value of 11 % as compared with less than 1 % in the endosperm. The germ provides about 78 % of the whole kernel minerals. Hence the mineral contents of *idli* prepared from whole corn kernels were found to contain all major and minor minerals.

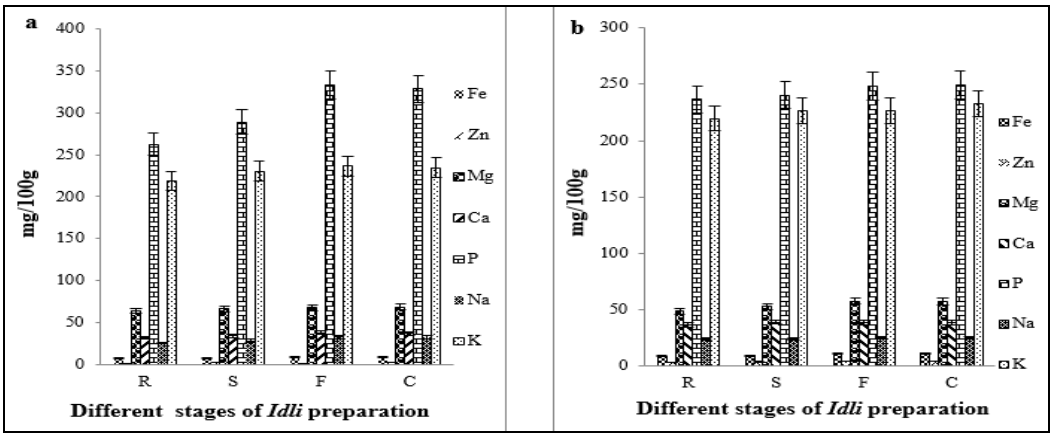

Fig 1: Changes in minerals composition of *idli* at different levels of preparation a) Maize, b) Rice. R: Raw, S: Soaked, F: Fermented, C: Cooked. * Significant @ $p \leq 0.05$

3.5 Anti nutrient contents of maize *idli* at different stages of preparation

As per Fig 2, the content of anti-nutrients reduced significantly from raw to cooked stage The phytic acid (927.76 to 533.32 mg in maize, 389.46 to 116.50 mg in rice), polyphenol (521.23 to 193.40 mg in maize, 329.89 to 94.99 mg in rice) and tannin (179.88 mg to 95.91 mg in maize, 109.84 to 75.97 mg in rice) content were reduced. The reduction was significant between the samples and between the stages of preparation. Phytic acid (Fig 2a) and polyphenol contents (Fig 2b) reported in this study were found to be more for maize samples compared to rice samples. This was due to the fact that phytic acid content varies significantly among the genotypes in maize. As per Sokrab *et al*., (2012) the content of phytic acid in raw maize varied from 1047.00mg and 87.16 mg/100 g for different maize varieties, while polyphenols content ranged between 460.50 and 363.70 mg/100 g. Our results are in agreement with this, where in after 14 h of fermentation significant reduction of phytic acid and polyphenols was noticed. It has been reported that appreciably high amount of protein content was observed to be associated with phytate content. As the protein content increased, phytate levels also increased and this holds good for maize since it contains high protein content (11.12 %) However, the phytic acid content of maize *idli* was found to be less than the values reported by Sokrab *et al.,* (2012) which might be due to the lime treatment of maize grains before milling.

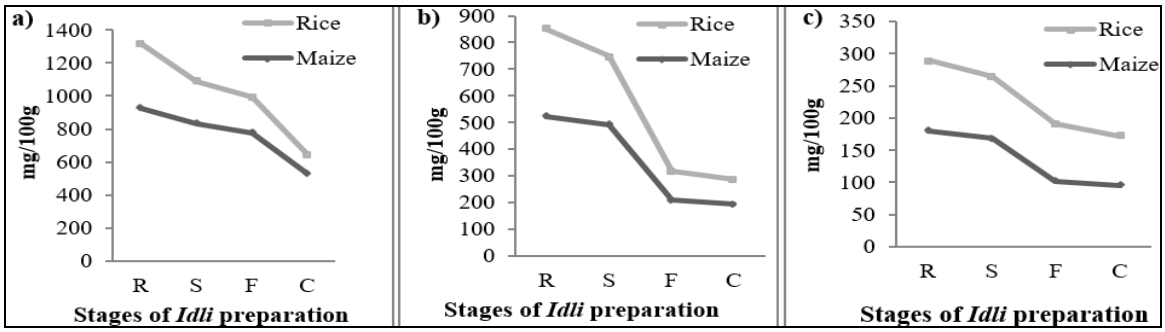

Fig 2: Changes in Phytic acid Polyphenols and Tannin during different stages of *Idli* preparation a) Phytic acid; b) Polyphenol; c) Tannin. R: Raw, S: Soaked, F: Fermented, C: Cooked.*Significant@ $p \leq 0.05$

Khandelwal *et al.*, (2010[33]) examined the effects of processing such as soaking, germination and pressure cooking in pulses; several possible reasons have been suggested for reductions in polyphenol and tannin concentrations upon soaking. Losses may result simply from leaching into the soaked water. Losses may also be attributed to decrease in extractability as lower molecular weight phenolic compounds polymerize thus becoming insoluble in water. (Abdelseed *et al.,* 2011) observed that the level of phytic acid in sorghum seeds reduced by more than 50 % during the fermentation period. The low pH (4.9) of the fermented flour may have provided a favorable condition for phytase activity. Phytate-degrading enzymes have been detected in various bacterial genera, such as *Bacillus* and *Pseudomonas* (Kerovuo *et al.,* 2000) [34]. Other researchers have reported a decrease in the level of phytic acid during fermentation due to phytase activity in the fermented flour (Kerovuo *et al.,* 2000; Abdel Rahaman *et al.,* 2005) [35].

3.6 Protein and starch digestibility of *idli* at different stages of preparation

The result of protein and starch digestibility is depicted in Fig.3. The protein digestibility increased from raw to cooked stage in both the samples (55.78 to 83.37 % in maize *idli*, 59.76 to 84.76 % in rice *idli*). The starch digestibility increased from raw to cooked stage (44.27 to 67.51 % in maize, 49.41 to 67.64 % in rice). The protein and starch digestibility was found to be increased in each level from raw to cooked stage in maize as well as control products, indicating that the processing methods such as soaking, fermentation and cooking significantly improved the *in vitro* protein and starch digestibility of the products. Raihanatu *et al*., (2011) [36] reported that fermentation improved the *in vitro* protein digestibility of cereals such as sorghum and pearl millet and this could be attributed to the partial degradation of complex storage proteins into more simple and soluble products. This increase may be due to the fact that fermentation led to changes in the endosperm protein fractions which make protein more accessible to the digestive enzymes.

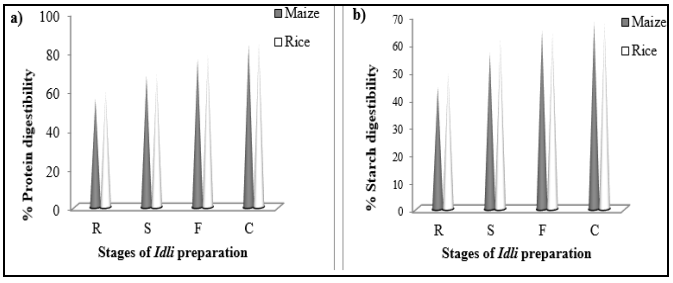

Fig 3: Changes in Protein and Starch digestibility during different stages of *Idli* preparation a) Protein digestibility %; b) Starch digestibility %; R: Raw, S: Soaked, F: Fermented, C: Cooked.*Significant @ $p \leq 0.05$

4. Conclusion

An acceptable maize *idli* can be prepared by fermenting maize semolina and black gram dhal in 3:1 ratio. The sensory, color and textural scores of the maize *idli* in 3:1 ratio was found to be significantly superior compared to rest of the combinations tested. The quality of *idli* indicated improvement in protein and minerals upon fermentation and cooking. Significant improvement in the protein and starch digestibility with a concomitant reduction of phytic acid, tannin and poly phenols was observed from raw to cooked stage in maize as well as rice *idli.* Thus, study indicated that traditional food processing technique such as fermentation can significantly contribute for the improvement of organoleptic and nutritional quality in lesser known cereal products like maize *idli.*

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