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Effect of Fermentation on the Nutritive Value, Bioavailability of Minerals and Acceptability of Pearl Millet Idli

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ABSTRACT:

Millets form the main source of calories and protein in the driest and poorest regions of the world. They are widely cultivated and consumed in several forms after cooking. Millets are nutritionally superior to other staples. However, the presence of antinutrients like phytic acid, tannins and polyphenols reduces the bioavailability of minerals. Processing methods like fermentation and germination have shown considerable reduction in the antinutrient content. Idli is an easily digested and popular fermented rice based food product, particularly in South India. Considering the positive aspects of both millets and idli, the present study was undertaken and pearl millet idli was prepared wherein pearl millet was used instead of rice. A comparison of the nutritive value, extractability of minerals and acceptability of pearl millet idli with rice idli was made at 12 and 24 hours of fermentation respectively. Protein was found to be similar in both idlis whereas rice idli had more ash content which was found to decrease when the fermentation period was increased to 24 hours. Pearl millet idli had more calcium, iron and phosphorus than rice idli. Studies indicate that fermentation reduces antinutrients like phytic acid, polyphenols, oxalates, thereby improving the availability of minerals like calcium, iron, zinc. The results in this study indicate that the extractability of minerals improved considerably which can be attributed to the decreased antinutrient content in fermented foods. The availability of Calcium doubled in both idlis when the period of fermentation was increased from 12 hours to 24 hours. Sensory evaluation showed that pearl millet idli was acceptable despite its peculiar odour.

Keywords: Millets, pearl millet idli, fermentation, mineral bioavailability.

INTRODUCTION:

Food grains have an important role to play in the diets throughout the world. Millets are small seeded cereals used for food, feed and forage. They are a staple in the diets of African and Asian people and were found to be a major source of calories and proteins. Unfortunately, the role that millets play in the nutrition of rural people has always been underestimated. The worldwide food shortage in recent years has aroused renewed interest in millets (Ravindran, 1990). Millets are termed as 'nutri-cereals' owing to their high nutritive value. (Bhat et al., 2018). They are also rich sources of biologically active compounds and have several health benefits like reduced fat absorption and low glycemic index (Kumar A et al., 2018), which can provide a possible solution to exponentially increasing lifestyle disorders like diabetes, hypertension, and obesity. Millet cultivation in India in 2019 was 1,211.4 kg/ha (FAOSTAT,

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2019). In India, millet consumption in rural areas (58.6%) was reported to be higher than in urban (27.5%) populations (NSSO, 2012). Studies state that in the past few decades, millet consumption globally has declined; per capita consumption of millets fell from 4.6 in 1982 to 3.6 kg, while in India in 1982 it was 12 kg and 8 kg in 2009 (Rao and Basavaraj, 2015).

Reduced millet consumption can be attributed to the regular availability of rice and wheat through the public distribution system, increased per capita income, urbanization, and evolving tastes and preferences (Bhagavatula et al., 2013). Therefore, the consumption in households has shifted to refined cereals. However, millet consumption has increased from 43.2 million metric tons (MMT) to 45.4 MMT, from 2018 to 2019 (Wallace and Singh, 2019). Millets are commonly consumed in the form of porridge, rotis (Indian flat bread), dumplings or are cooked with vegetables (Rao et al., 2006). Traditional methods like boiling, soaking, germination, fermentation, popping and flaking are employed. Many food industries and research institutes have developed ready-to-eat and ready-to-cook millet products like dehulled millets, semolina, vermicelli, pasta and millet-rich multigrain rotis (Sheetal et al., 2022). Millets are now increasingly used to prepare foods like multigrain cereal flours and gluten-free products (Saleh ASM et al., 2013).

Several studies reported the positive health benefits of millets – contain high protein, essential fatty acids, dietary fiber, B vitamins and minerals, such as calcium, iron, zinc, potassium, and magnesium. Additionally, they render other benefits like reduction in blood sugar level, lowered blood cholesterol and pressure regulation, prevention of thyroid disorders, reducing the risk of cardiovascular disease, celiac disease, and many other age-related chronic diseases (Jacobs et al., 1995, 1998; Liu et al., 1999, 2000; Anderson et al., 2000; Meyer et al., 2000; Nicodemus et al., 2001; Liu, 2002; Anitha et al., 2021). However, other studies report the presence of antinutrients that hinder nutrient absorption in humans. Millets have about 0.61% of tannin, 0.48% of phytic acid, 0.2–3.0% of polyphenol and trypsin inhibitors (Thompson, 1993). The phytic acid content in millets have reduced considerably by the traditional processing methods. Traditional Indian cooking methods like pressure cooking, prolonged boiling, steaming, etc. have been reported to show more reduction when compared to other countries (Agte et al., 1999). Furthermore, soaking, fermentation, and germination also reduced the phytic acid content (Liang et al., 2008) in millets. Studies suggest that fermentation provides optimum pH to lower phytic acid and increase the availability of minerals and vitamin B (Haard, 1999).

Fermented foods are being used by people in their daily diets in many countries and are generally considered highly nourishing. However, very little information is available on the nutritive value of fermented foods (Khambatta and Dastur, 1950; Sundararanjan, 1950; Balasubramanian et al., 1955). It is reported that during the process of fermentation, vitamins and proteins are formed and supplements of these nutrients of microbial origin enhance the nutritive value of restricted vegetarian diets (Macrae et al., 1942; Klose and Fevold, 1945; Garibaldi et al., 1953). Several methods have been employed to improve the nutritional quality of cereals. Fermentation is one of the oldest methods and is widely used to process cereals and millets (Osman, 2011). Several research studies report that fermentation can be

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effectively used to improve the nutritional quality of cereal grains (Inyang and Zakari, 2008; Ali et al., 2003; El Hag et al., 2002). Fermentation was also found to decrease trypsin inhibitory activity (TIA), amylase inhibitor activity, phytic acid, and tannins (Osman, 2004; Ejigui et al., 2005; Eltayeb et al., 2007; Abdel-Haleem et al., 2008).

Idli is a popular, fermented rice-based food product of South India. It is a steamed product prepared from a thick, fermented batter of rice and black gram dhal in a ratio of 2:1 (Lewis and Johar, 1954-55; Radhakrishna Murthy et al., 1961). Idli is an easily digestible product. Idli is a good source of protein, calories and vitamins, especially B-complex vitamins. Research reports that maximum riboflavin (0.76 mg/100 g) and thiamine (0.73 mg/100 g) content were found in idli batter prepared from rice and black gram (3:1) blend, and the folic acid content was found to be maximum (0.75 mg/100 g) after 10 hours of fermentation (Ghosh and Chattopadhyay, 2010). Millets are probably the world's earliest food plants used by humans, and certainly the first cereal grain that was used for domestic purposes (Narpinder et al., 2007). Millet grains can be used as a substitute for rice or wheat components of fermented foods like dosa or idli (Manay and Shadaksharaswamy, 2001).

Envisaging the nutritive aspects of millets and the fermented product – idli, millet idli has been developed using the locally available Pearl millet in place of rice. The main objective of the study was to compare pearl millet idli and rice idli with regards to nutritive value and acceptability at 12 and 24 hours of fermentation period respectively.

MATERIAL AND METHODS:

Procurement of Sample:

Pearl millet was purchased from the local market in Anantapur. The seeds were cleaned of stones and other extraneous matter and dried in the sun. The cleaned seeds sample was then stored in a polythene bag at room temperature till analysed for various parameters.

Preparation of Idli:

Standard idli or rice idli was prepared using rice and black gram dhal in the ratio of 2:1 (Lewis and Johar, 1954-55, Radhakrishna Murthy et al., 1961). The weighed ingredients were soaked for 12 hrs and then ground separately to a smooth paste and mixed. Salt was added to taste. The batter was fermented at 37°C for 12 hrs and 24 hrs and idlis were prepared. For Pearl millet idli, Pearl millet was used instead of rice and the procedure as above was followed. Moisture content of the idlis was estimated (AOAC, 1985). All the samples were dried at 100°C for one hour in an oven and then powdered using a motor and pestle. The powdered samples were used for further analysis.

Chemical Analysis:

The idli samples were used for the estimation of proximate principles, minerals, antinutrients and extractable minerals. The samples were analysed for proximate principles – protein, fat, fiber and ash using the AOAC (1985) method. Carbohydrate content was estimated using the difference method given by Ranganathan et al., 1937. Calorific value was obtained by

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calculation (Ranaganathan et al., 1937). For mineral analysis, the samples were ashed according to the AOAC method (1985) and dissolved in Hcl. The ash solution was used for estimation of calcium, iron and phosphorus. Calcium was estimated by ammonium oxalate and potassium permanganate titrimetric method as given by Hawk et al., 1957. Wong's method and Fiske Subba Rao's method given by Raghuramulu et al., 1983, was used to estimate the iron and phosphorus content in the idli samples respectively. The extractable calcium, iron and phosphorus content was estimated by the method given by Peterson et al., (1943).

Sensory evaluation:

Idli samples in covered petridishes were code numbered and presented randomly to a panel of about 10 judges who scored them sequentially. Samples were scored for hardness, stickiness, appearance, odour and taste according to a score card (**Table1**), in which the highest score corresponded to the highest perception of quality.

Table 1

Table 1: Score card for idli evaluation. **Name:** **Date:**

I.	**Hardness**	1. Very hard
		2. Rather hard
		3. Medium
		4. Rather soft
		5. Very soft
II.	**Stickiness**	1. Very Sticky
		2. Rather sticky
		3.Medium
		4. Rather soft
		5. Very soft
III.	**Appearance**	1. Smooth
		2. Slightly porous
		3. Porous
IV.	**Odour**	1. Off odour
		2. Slight off odour
		3. Good odour
V.	**Taste**	1. Too sour

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2. Slightly sour
3. Bland

Statistical analysis:

The mean values were calculated and the variation was found by calculating the standard deviation. Student's 't' test was applied to find the significant difference among the samples. Statistical analysis was done to find out the significant difference among the variations of the groups by applying analysis of variance (ANOVA), Gupta, 1991.

RESULTS AND DISCUSSION:

Proximate composition:

The moisture content of standard idli at 12 and 24 hrs of fermentation was found to be 13.04 ± 0.056 and 15.93 ± 0.021 g% respectively which is much less than that of pearl millet idli (23.26 ± 0.028 and 19.73 ± 0.006 g%). Protein content of standard idli was estimated to be 13.06 ± 0.092 (12 hrs) and 13.00 ± 0.176 (24 hrs) g%. Pearl millet idli at 12 and 24 hrs of fermentation had 13.17 ± 0.058 and 13.06 ± 0.092 g% protein which is almost similar to that of standard idli. The increase in the period of fermentation did not seem to affect the protein content of both the idlis. The fat content of standard idli at 12 hrs of fermentation was estimated to be 1.73 ± 0.008 while the 24 hrs sample had a lesser fat content of 1.47 ± 0.009 g%. The fat content of pearl millet idli was found to be 0.62 ± 0.011 and 0.64 ± 0.005 g% at 12 and 24 hrs of fermentation respectively which is comparatively less than that of standard idli. The fiber content of rice idli and pearl millet idli was estimated to be 1.53 ± 0.022 and 1.93 ± 0.012 g% respectively at 12 hrs of fermentation. At 24 hrs of fermentation the fiber content was found to decrease to 1.33 ± 0.016 (standard idli) and 1.83 ± 0.021 (pearl millet idli) g%. However, pearl millet idli was found to be more fibrous than standard idli. The ash content of standard idli was found to be 3.53 ± 0.021 (12 hrs) and 2.24 ± 0.012 (24 hrs) g% while pearl millet idli contained 3.25 ± 0.008 and 2.51 ± 0.012 g% of ash at 12 and 24 hrs of fermentation respectively which was comparatively lesser than the standard idli. The increase in the period of fermentation decreased the ash content in both the idlis significantly. The carbohydrate content of standard idli was calculated to be 62.11 ± 0.031 and 66.03 ± 0.137 g% at 12 and 24 hrs of fermentation respectively. Pearl millet idli was found to contain 57.76 ± 0.087 and 62.24 ± 0.058 g% of carbohydrates at 12 and 24 hrs of fermentation. Calculations revealed the calorific value of standard idli and pearl millet idli to be 361.25 ± 0.342 and 289.33 ± 0.153 Kcal at 12 hrs of fermentation and at 24 hrs of fermentation it was found to be 329.32 ± 0.217 and 306.92 ± 0.125 Kcal respectively. The proximate composition of standard idli and pearl millet idli is given in **Table 2**.

Table 2: Proximate Composition of Idli (Mean ±SD)

Sample	Treatment	Moisture	Protein	Fat	Fiber	Ash	Carbohy -drates	Calorific value

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Standard Idli	**Fermented 12 hrs**	13.04 ± 0.056	13.06 ± 0.092	1.73 ±0.008	1.53 ±0.022	3.53 ±0.021	62.11 ±0.031	361.25 ±0.342
	Fermented 24 hrs	15.93 ±0.021	13.00 ±0.176	1.47 ±0.009	1.33 ±0.016	2.24 ±0.012	66.03 ±0.137	329.32 ±0.217
Pearl Millet Idli	**Fermented 12 hrs**	23.26 ±0.028	13.17 ±0.058	0.62 ±0.011	1.93 ±0.012	3.25 ±0.008	57.76 ±0.087	289.33 ±0.153
	Fermented 24 hrs	19.73 ±0.006	13.06 ±0.092	0.64 ±0.005	1.83 ±0.021	2.51 ±0.012	62.24 ±0.058	306.92 ±0.125

All the values are expressed as g/100g on dry weight basis.

Mineral Composition: Calcium, iron and phosphorus content of standard idli and pearl millet idli at 12 and 24 hrs of fermentation period is given in **Table 3** and **Figure 1**. The calcium content of standard idli was estimated to be 93.03 ± 0.044 (12 hrs) and 93.60 ± 0.031 (24 hrs) mg%. Pearl millet idli had 116.23 ± 0.028 and 116.22 ± 0.076 mg% calcium at 12 hrs and 24 hrs of fermentation respectively which is significantly higher than that present in the standard idli. It has been noted that the period of fermentation did not seem to have much effect on the calcium content of the idlis. Standard idli was found to contain 7.60 ± 0.082 and 7.62 ± 0.174 mg% of iron at 12 and 24 hrs of fermentation. A significant increase from 13.15 ± 0.0431 (12 hrs) to 13.26 ± 0.045 (24 hrs) mg% was noticed in the iron content of pearl millet idli which was comparatively more than the standard idli. The period of fermentation did not seem to have any effect on the iron content of standard idli, but a slight increase was noticed in pearl millet idli. The phosphorus content of standard idli was found to be 179.90 ± 0.117 (12 hrs) and 220.00 ± 0.062 (24 hrs) mg%. Pearl millet idli contained 200.63 ± 0.446 mg% at 12 hrs of fermentation and 210.03 ± 0.008 mg% at 24 hrs of fermentation. There was a remarkable increase of phosphorus in the standard idli and pearl millet idli when the time period of fermentation was increased from 12 to 24 hrs.

Table 3: Mineral composition of Idli (Mean±SD)

Sample	Treatment	Calcium	Iron	Phosphorus
Standard Idli	**Fermented 12 hrs**	93.03 ± 0.044	7.60 ± 0.082	179.90 ± 0.117
	Fermented 24 hrs	93.60 ± 0.031	7.62 ± 0.174	220.00 ± 0.062
Pearl Millet Idli	**Fermented 12 hrs**	116.23 ± 0.028	13.15 ± 0.041	200.63 ± 0.446

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	Fermented 24 hrs	116.22 ± 0.076	13.26 ± 0.045	210.03 ± 0.088

All values are expressed as mg/100g on dry weight basis.

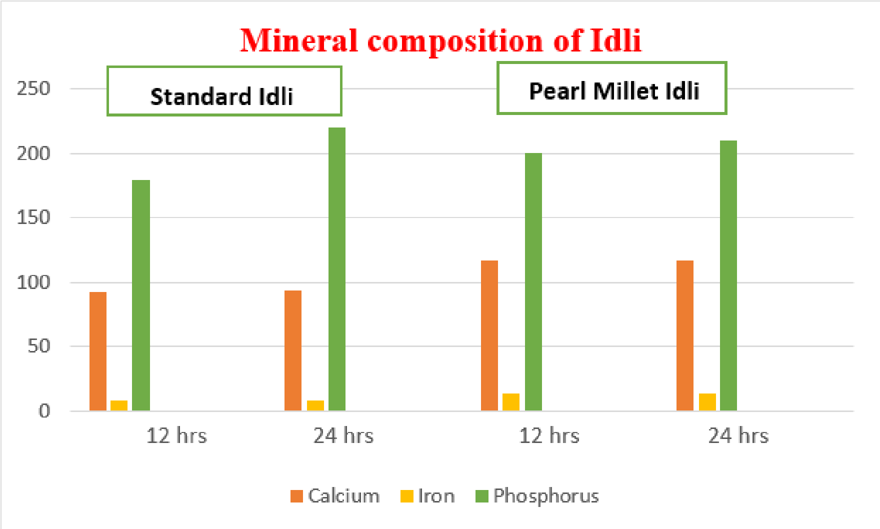

Figure 1: Graphical representation of the mineral composition of standard and pearl millet Idli

Mineral Extractability: Extractability of Calcium, Iron and Phosphorus in standard and pearl millet idli is given **Table 4** and **Figure 2.** The extractability of calcium in standard idli was found to be 25.06 ± 0.048 (12 hrs) and 40.13 ± 0.046 (24 hrs) %. Calcium extractability of pearl millet idli was found to be more (40.16 ± 0.124 and 80.15 ± 0.038 %) than the standard idli at both 12 and 24 hrs of fermentation. Calcium extractability increased when the period of fermentation was increased from 12 to 24 hrs in both idli samples but the increase doubled in pearl millet idli. Iron extractability of standard idli and pearl millet idli was found to increase from 66.68 ± 0.00 (12 hrs) to 66.71 ± 0.031 (24 hrs) and 57.13 ± 0.015 (12 hrs) to 57.50 ± 0.081 (24 hrs) % respectively. Pearl millet idli was found to show less extractability of iron than the standard idli. The extractability of phosphorus was estimated to be 67.77 ± 0.03 and 68.47 ± 0.093 % at 12 and 24 hrs of fermentation in the standard idli. Phosphorus extractability of pearl millet idli was found to be lesser (60.30 ± 0.0142 and 65.0 ± 0.079%) than standard idli.

Table 4: Mineral extractability of Idli (Mean±SD)

Sample	**Treatment**	**Calcium**	**Iron**	**Phosphorus**
Standard Idli	**Fermented 12 hrs**	25.06 ± 0.048	66.68 ± 0.0	67.77 ± 0.093
	Fermented	40.13	66.71	68.47

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	24 hrs	± 0.046	± 0.031	± 0.093
Pearl Millet Idli	**Fermented 12 hrs**	40.16 ± 0.124	57.13 ± 0.015	60.3 ± 0.142
	Fermented 24 hrs	80.15 ± 0.038	57.5 ± 0.081	65.0 ± 0.079

All values are expressed on dry weight basis

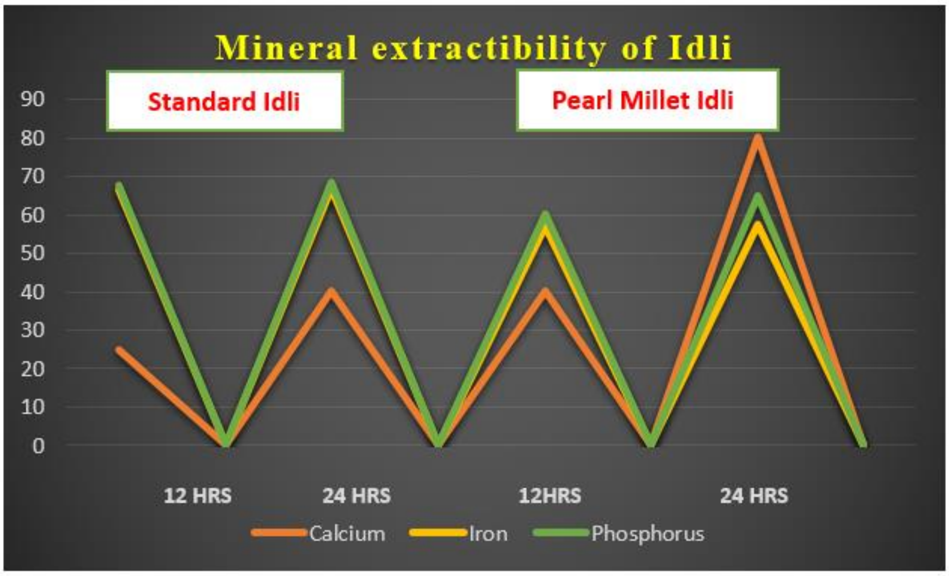

Figure 2: Graphical representation of the extractability of minerals of standard and pearl millet Idli

Acceptability of the Fermented product – Pearl Millet Idli

Standard or rice idlis and pearl millet idlis were assessed for the following qualities – hardness, stickiness, appearance, odour and taste (**Table 5)**. Fermentation period did not seem to have any effect on the hardness and appearance of rice idli. However, 24 hrs of fermentation affected the stickiness, odour and taste in all idli samples. Twenty four hours idli was found to be more stickier having a strong odour and a different taste. Fermentation for 24 hrs was found to increase the hardness of the idli and the taste also varied. Pearl millet idli was compared with standard idli and it was found that pearl millet idli had a peculiar and strong odour and taste which was different from the standard idli.

Table 5: Acceptability of the fermented product Idli (Mean±SD)

Sensory Quality	**FERMENTATION**	
	12 hrs	**24 hrs**

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	Standard Idli	Pearl Millet Idli	Standard Idli	Pearl Millet Idli
Hardness	4.0 ± 0.21	3.6 ± 0.36	3.9 ± 0.80	3.4 ± 0.15
Stickiness	4.1 ± 0.35	3.1 ± 0.45	3.5 ± 0.007	2.9 ± 0.65
Appearance	2.8 ± 0.60	1.9 ± 0.08	2.9 ± 0.08	2.0 ± 0.79
Odour	2.7 ± 0.08	1.4 ± 0.06	2.6 ± 0.009	1.2 ± 0.42
Taste	2.8 ± 0.15	1.5 ± 0.18	2.6 ± 0.12	1.2 ± 0.07

CONCLUSION:

The present investigation was undertaken to study the effect of fermentation on the nutritive value, bioavailability of minerals and acceptability of pearl millet idli. Pearl millet idli was found to contain similar protein, lesser fat, ash and carbohydrates when compared to the standard idli. The calcium, iron and phosphorus content in pearl millet idli was comparatively more. While iron and phosphorus extractability was more in the standard idli, the extractability of calcium was found to be significantly higher in pearl millet idli.

The 24 hour fermentation method brought about a considerable reduction in certain major nutrients like fat, fiber and ash when compared to 12 hour fermentation. Calcium extractability almost doubled at 24 hour of fermentation, but there was not much difference in the protein content and mineral content.

Sensory evaluation revealed that pearl millet idli acceptability was similar to that of the standard idli although pearl millet idli had a unique flavor. Moreover, the 12 hour fermented idli was better accepted than the 24 hour fermented idli. Considering the nutritional qualities of pearl millet idli, 12 hour fermented pearl millet idli was found to be more advantageous and it can be consumed despite its unique odour. The strong flavour of Pearl millet idli can be reduced by addition of certain vegetables like carrot, green peas or spices like ginger and chillies.

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