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Standardization of fermented minor millet-based instant dosa mixes and evaluation of their physico functional, nutritional and phytochemical properties

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Abstract

Rapid industrialization and urbanization and consequent changes in people's eating habits have led to the development of instant dry mixes and ready-to-eat convenience foods. Dry mixes of several traditional Indian foods such as dosa mix have gained worldwide popularity. Hence, instant millet dosa mix has less preparation time and can easily fit into the kitchen of modern urbanites as a healthy option. The instant mixes from minor millets can help in adding variety to the diet make the diet rich in micronutrients and satisfy the demand for small millets processed foods. Processing small millet-based instant food mixes would be a successful strategy to promote millet utilization. Hence, the present investigation was undertaken to standardize nutritious instant dosa mixes from small millets with other ingredients that were on par with traditional dosa in sensory properties and nutritional composition. In the present study, the protocol was standardized using fermented different minor millet grains to make instant dosa mixes. This study standardized four dosa mixes with kodo (80%), proso (100%), little (80%) and barnyard millet (70%) with 24, 24, 24 and 12 h of the fermentation period. Further analysis of the nutritional and phytochemical constituents of the dosa mix revealed that all the nutrients were significantly different from each other. The proso millet dosa had the highest protein (16.39%) and crude fiber (1.99%), little millet had the highest total and available carbohydrates (73.70%), barnyard millet had the highest ash (6.72%) whereas, little millet dosa provided the highest energy (364 kcal). As all the standardized instant dosa mixes had more than 50 per cent of millet, they can be categorized as millet-based dosa mixes.

1. Introduction

Millets have their origin in ancient history primarily small millets. Proso millet (Chinaka), one among small millets, is believed to be one of the ancient grains of mankind and barnyard millet (Aanava) was mentioned in mythological scriptures of Yajurveda (Rahul Banerjee *et al.*, 2024) while little millet (Anu), one among time-honored grains commonly known as esculent or small rice and kodo (Kodrva) also one among Indian origin grains (Shivanshu Garg *et al.*, 2024). At present, these small millets comprise six species; namely, finger millet (*Eleusine coracana* Gaertn.), little millet (*Panicum sumatrense* Roth.), Italian or foxtail millet (*Setaria italic* L.), barnyard millet (*Echinochloa crusgalli* L.), proso millet (*Panicum miliaceum* L.) and kodo millet (*Paspalum scrobiculatum* L.) are commonly grown in India (Bhag Mal *et al.*, 2010). Despite being a leading millet-producing country globally, India encountered a small millet recession at one point in its history and flagged it as a minor millet or underutilized crop.

Minor millets, an abode of major and minor nutrients, are also a good source of essential amino acids and fatty acids. It was suggested that millets possess nutraceutical properties as they contain a good amount of phytochemicals (lignans, β -glucan, inulin, resistant starch, phytates, sterols, tocopherol and carotenoids) and are gluten-free. It was also suggested that due to the presence of phytochemicals, millets can play an important role in the prevention of many non-communicable diseases and are excellent food choices for people suffering from celiac disease (Arora *et al.*, 2022).

The barnyard millet contains carbohydrates that are slowly digestible and it is a fair source of highly digestible protein, lipids, vitamins like thiamine, riboflavin, and nicotinic acid compared with other cereals, such as rice and wheat grains. However, barnyard millet shows the highest concentration of iron (40.2 ppm), followed by finger millet (34.15 ppm) (Karakannavar *et al.*, 2021). Proso millet has a protein content of 11%, 3.5% fat, 9% crude fiber, 3.6% ash, 56.1% starch, 8.5%-total dietary fiber, calcium-165 mg/kg, iron-54 mg/kg, zinc-36 mg/kg and vitamins like B complex vitamins. Proso millet contains a good amount of amino acids, particularly sulfur-containing ones such as cysteine and methionine (Arora *et al.*, 2022). Little millet is rich in crude fiber, iron and phosphorus that are comparable to cereals and other millets. Regular consumption of little millet is very beneficial for postmenopausal women suffering from signs of cardiovascular disease, like high blood pressure and high cholesterol levels. Additionally, it can blend with most traditional and novel foods without imparting any flavors of its own (Jain and Shekhar., 2021).

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The kodo millet grain is composed of 8 per cent protein. It is an excellent source of fiber (9%), as opposed to rice (0.2%), and wheat (1.2%). Kodo millet provides 66.6 g of carbohydrates and 353 kcal per 100 g of grain, comparable to other millets. It also contains 1.4 per cent fat and 2.6 per cent minerals (Deshpande *et al.*, 2015).

Value addition through the processing of minor millets can be explored and commercialized to make them popular among consumers. The traditional fermentation process involves mixed microbial cultures and the major transformations occur during the process, *viz.*, starch hydrolysis, sugar transformation, improvement of protein, mineral availability and grain softening (Thirumangaimannan and Gurumurthy, 2013). Compared to other common cereals, millet has countless advantages from a nutritional point of view, which are amplified during fermentation (Balli *et al.*, 2023).

Dosa is an Indian traditional food. However, preparation of these involves time-consuming steps such as soaking, wet grinding and fermentation of the batter. The drudgery of preparing dosa can be overcome by using instant mix. Besides providing convenience the instant mix ensures uniform quality (CFTRI). Instant dosa mix is a ready-to-cook product to overcome the problems faced in the processing of dosa batter. Several studies have explored millet-based instant mixes, addressing their nutritional benefits, sensory and shelf-life but more studies focus on a few millet types (kodo, foxtail, finger millet and browntop) whereas underutilized remains unexplored (Vijaya Laxmi *et al.*, 2020; Mahalakshmi, 2023; Selvaraj *et al.*, 2018; Verma *et al.*, 2023). The present study focussed on a comprehensive evaluation of instant dosa mixes using four minor millets-kodo, proso, little and barnyard millet. Various fermentation periods were analyzed to optimize the process and standardized dosa mix preparation. The

main objective was to enhance the utilization and convenience while evaluating the influence on millet flours, sensory attributes, nutritional and phytochemical composition and storage stability of minor millet-based instant dosa mix.

2. Materials and Methods

Raw material required for the study was purchased from the local market of Hyderabad. The purchased grains were cleaned from physical impurities and further utilized for the study. The other ingredients were purchased from Sai Techno Youth Association, Rythu Bazar, Hyderabad.

2.1 Standardization of instant dosa mix

Minor millet instant dosa mixes were developed by the process given in Figure 1. The grains (proso, kodo, little and barnyard millets along with rice (control) and black gram dal) were soaked for 6 h, steeped and fermentation was done in different time intervals and dried in a cabinet drier for 10-15 h at 60°C up to 8 per cent moisture. Dried millets and other ingredients were pulverized and flour and fine grits were separated using a basic standard sieve (BSS) 60 mesh sieve. The different formulations with the addition of additives with different per centages were mixed and packaged in LDPE covers for further study (Table 1). Dosa was prepared by the procedure given in Figure 2. Standardized and formulated products were subjected to sensory evaluation using a 9-point Hedonic scale (Meilgaard *et al.*, 1999) with semi-trained panel members to select the best formulation. The acceptability index was calculated by summing up all the sensory scores of appearances, texture, flavor, taste and overall acceptability and it was divided by maximum score and multiplied by 100.

$$\text{Acceptability index (AI)} = \frac{\text{Total scores}}{\text{Maximum score}} \times 100$$

Table 1: Formulation of instant millet-based dosa mix

Ingredients	Control	Millet 100%	Millet 80%	Millet 70%
Millet flour (g)	-	71.25	57.0	49.86
Rice flour (g)	71.25	-	14.25	21.37
Black gram flour (g)	25.0	25.0	25.0	25.0
Salt (g)	2.5	2.5	2.5	2.5
Methi powder (g)	0.25	0.25	0.25	0.25
Rice flakes powder (g)	0.75	0.75	0.75	0.75
Baking soda (g)	0.25	0.25	0.25	0.25

Table 1 presents the formulations of instant millet-based dosa mixes with varying proportions of ingredients such as millet flour, rice flour, black gram flour, salt, methi powder, rice flakes powder and baking soda. The instant dosa mixes were prepared with 70, 80 and 100 per cent millet flour along with the corresponding amount of rice flour. The other ingredients were kept constant in all formulations. The control formulation was prepared without millet flour using 100 per cent rice flour.

Figure 1 shows the process of preparation of fermented millet flour. The millet grains were soaked for 6 h in water, followed by

fermentation for 12 h, 24 h, and 42 h. The water was changed every 12 h. After fermentation completion, the water was drained and grains were dried at 60°C for 10-15 h to maintain the moisture level up to 8%. The grains were pulverized and flour was separated using a BSS 60 mesh sieve. The flour was packed in LDPE covers for further use. To prepare dosa using dosa mix, 75 g of any dosa mix, 10 g of curd and about 35-40 ml of water are required. Mix the dosa mix with curd while gradually adding water until the batter reaches the desired consistency and rest the batter for 20-30 min. After the resting time, stir the batter continuously to incorporate air, which helps create a spongy and porous surface on dosa.

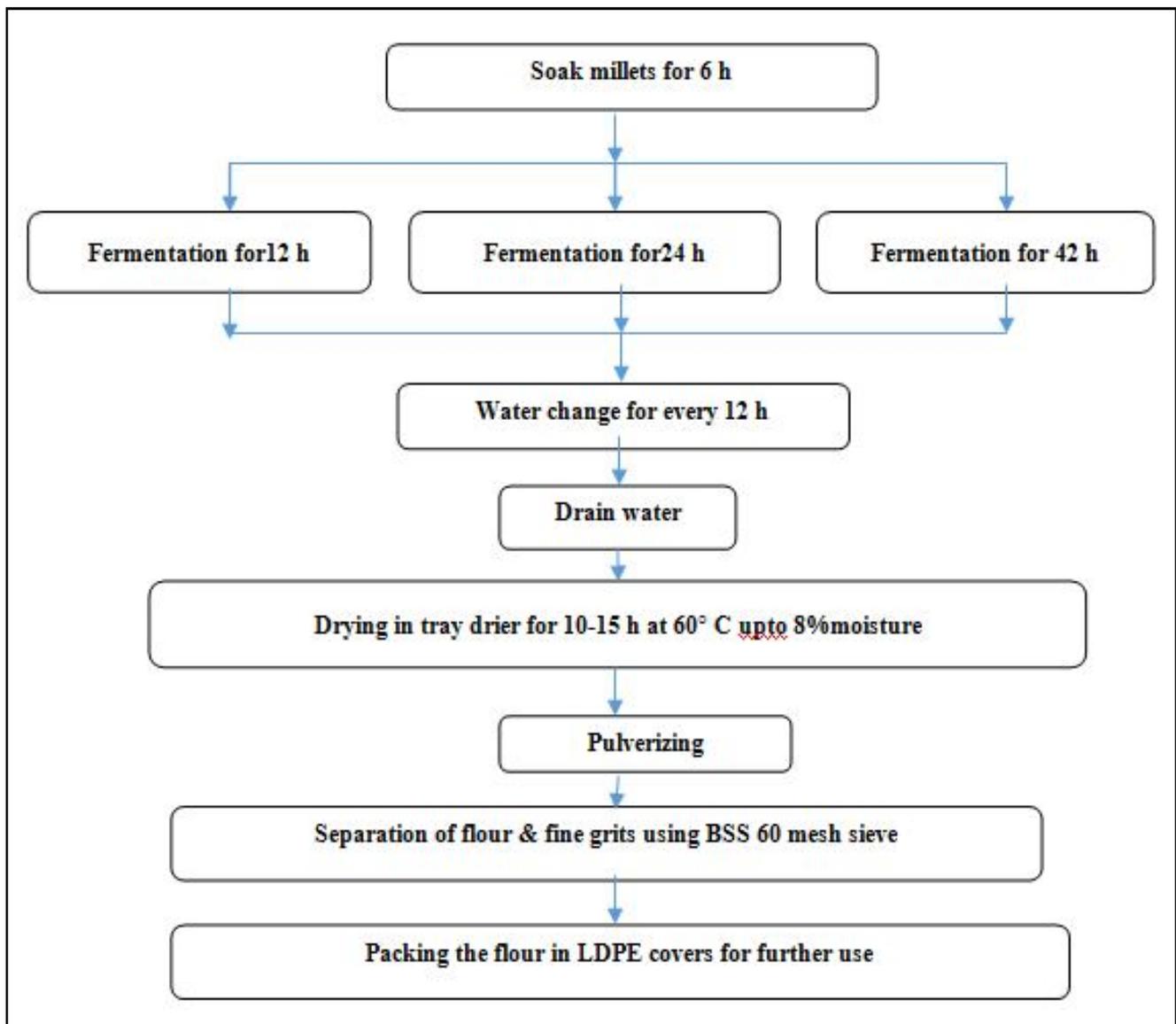


Figure 1: Flow chart for fermentation of millet grain.

2.2 Physicochemical characteristics of fermented millet

2.2.1 pH and titratable acidity

The pH of the coarsely ground grain was recorded at different fermentation times using a digital pH meter and total titratable acidity was estimated following the method of AOAC (1970).

2.2.2 Physicochemical characteristics of minor millet dosa prepared with instant millet dosa mixes

Physical characteristics of dosa prepared by using dosa mix, viz., diameter (cm), weight of 50 ml batter, cooking time (sec) and weight of the product after cooking (g) were measured (Karakannavar *et al.*, 2021).

2.2.3 Functional properties of instant dosa mix

Functional properties such as water solubility index expressed in per centage, swelling power expressed in per centage (Awoyale *et al.*, 2020), water holding capacity expressed in per centage (Mesias

and Morales, 2017), water absorption capacity expressed in g/ml (Sefa-Dedah and Agyir-Sackey, 2014), water and oil retention capacity expressed in g/ml (Grah Avit Maxwell and Beugre, 2014), hydrophilic-lipophilic index (Njintang *et al.*, 2007) of instant millet dosa mixes were analyzed.

2.2.4 Analysis of nutritional content of instant dosa mixes

Moisture and ash (IS: 1155-1968 reaffirmed 2010), carbohydrates (AOAC, 2006), protein (AOAC, 2010), fat and crude fiber (AOAC, 2005), minerals like calcium (mg/100 g) and magnesium (mg/100 g), iron (mg/100 g), zinc (mg/100 g) and phosphorous (mg/100 g) (AOAC, 2012) were analyzed following standard protocols.

2.2.5 Bioactive compounds

Antioxidants estimation using the DPPH method (% DPPH) and phytonutrients such as total phenols were estimated with gallic acid as standard and results were expressed in mg GAE/100 g and tannins were estimated with tannic acid as standard and results were expressed

in (mg/tannic acid/100 g) (AOAC, 2005), following standard procedures and standards purchased from National Traders, Hyderabad.

2.2.6 Storage studies

The final formulated minor millet dosa mixes were stored in polypropylene pouches and stored at ambient temperature for 120 days and microbial count examined in nutrient agar medium. Analysis of moisture (AOAC, 2005), total bacterial count (TBC) and total mold count (TMC) (Tambekar *et al.*, 2009) were done on the 30th, 60th, 90th and 120th day of storage expressed as cfu per ml.

2.3 Statistical analysis

SPSS statistical software (version 16, SPSS Inc) was used to perform the statistical analysis of the data. Analysis of variance (ANOVA), followed by Duncan's multiple range test was performed to determine significant differences at a 5 per cent level.

3. Results

3.1 pH and titratable acidity of fermented millet grains

The change in pH and titratable acidity of grains during fermentation in different time intervals are presented in Table 2. The pH of kodo

millet ranged from 5.39 to 5.09, proso millet ranged from 5.46 to 4.98, little millet ranged from 5.40 to 3.87 whereas, the barnyard millet ranged from 5.45 to 4.08 during the fermentation period of 12 to 48 h. Among all minor millet grains, little millet showed the lowest pH (3.87) during the fermentation. There was no significant ($p>0.05$) change in the pH of different millet grains during 12 h of fermentation. However, the pH of little millet (4.02) and barnyard millet (4.33) decreased significantly after 24 and 48 h of fermentation. The titratable acidity of different millets was significantly changed over the fermentation period of 12, 24 and 48 h. The titratable acidity of kodo millet ranged from 0.012 to 0.093, proso millet ranged from 0.018 to 0.045, little millet ranged from (0.045 to 0.072) and barnyard millet ranged from (0.036 to 0.072) during the fermentation period of 12 to 48 h. For all millets, the titratable acidity increased up to 24 h of the fermentation period but decreased after 48 h. Among the different millets, the barnyard millet showed the highest acidity, followed by kodo, proso and little millet after 24 h of fermentation. The results indicate that as the fermentation time increased, the pH of instant dosa mixes decreased due to an increase in titratable acidity. This may be because of the release of acids during the fermentation process by microorganisms.

Table 2: pH and titratable acidity of fermented millet grains

Sample	pH			Titratable acidity		
	12 h	24 h	48 h	12 h	24 h	48 h
KM	5.39 ± 0.11 ^a	5.16 ± 0.06 ^a	5.09 ± 0.10 ^a	0.012 ± 0.001 ^c	0.163 ± 0.038 ^b	0.093 ± 0.002 ^a
PM	5.46 ± 0.06 ^a	5.18 ± 0.06 ^a	4.98 ± 0.41 ^a	0.018 ± 0.004 ^c	0.140 ± 0.020 ^b	0.045 ± 0.028 ^b
LM	5.40 ± 0.05 ^a	4.02 ± 0.41 ^c	3.87 ± 0.16 ^b	0.045 ± 0.006 ^a	0.081 ± 0.019 ^c	0.072 ± 0.008 ^{ab}
BM	5.45 ± 0.07 ^a	4.33 ± 0.11 ^b	4.08 ± 0.07 ^b	0.036 ± 0.004 ^b	0.213 ± 0.006 ^a	0.072 ± 0.004 ^{ab}
F-value	0.873	145.079	21.672	43.078	16.386	5.378
SEM	0.039	0.048	0.133	0.016	0.055	0.020
CD	NS	0.190**	0.522**	0.000**	0.143**	0.101*

SEM-Standard error mean, CD-Critical difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p\leq 0.05$). KM: Kodo millet, PM: Proso millet, LM: Little millet, BM: Barnyard millet.

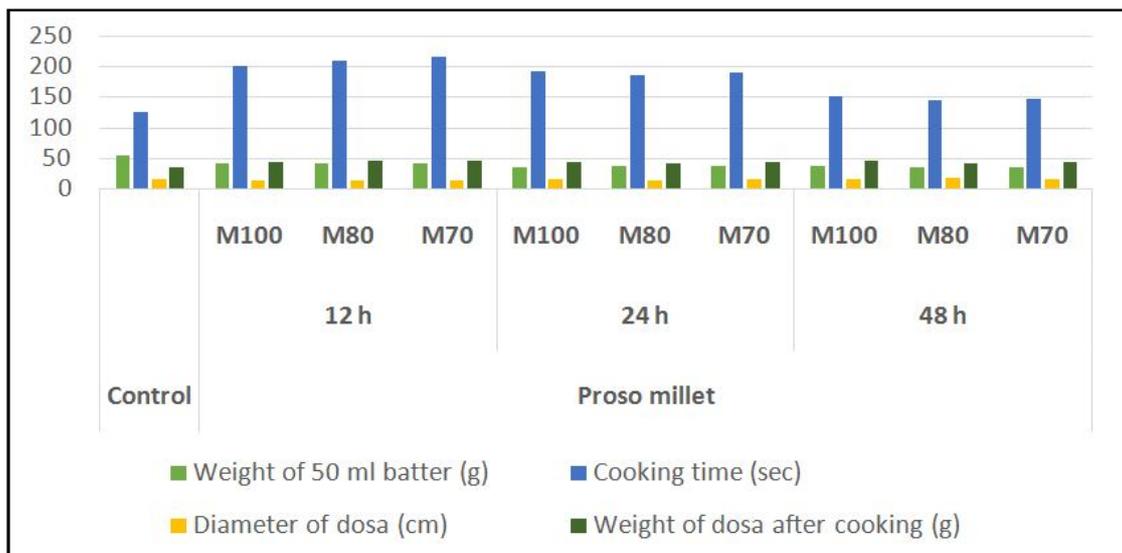


Figure 2: Physical parameters of proso millet dosa.

3.2 Physical parameters of millet dosa made with instant millet dosa mixes

Figure 2 shows the physical parameters such as weight of 50 ml of batter, diameter of dosa, cooking time and weight of proso millet dosa prepared with the instant mixes standardized with 100, 80 and 70 per cent of proso millet. The control dosa mix was prepared with rice flour and Bengal gram flour. The weight of the proso millet dosa batter prepared with different millet proportions (100, 80 and 70%) was lighter than the control dosa batter (54 g). The weight of proso

millet batter with 100, 80 and 70 per cent proso millet decreased on fermenting the grains for longer fermentation periods, *i.e.*, 12 h (40, 42 and 40 g), 24 h (35, 36 and 36 g) and 48 h (36, 34 and 34 g), respectively. The diameter of proso millet dosa prepared with different millet proportions and fermentation time ranged from 13 to 18 cm, the lowest (13 cm) being with 12 h fermented dosa (80% and 70%) and the highest (18 cm) being for 48 h of fermented dosa (80%) as compared to the control dosa (16 cm). The weight of cooked proso millet dosa ranged between (42-46 g) which was higher than the control dosa (35 g).

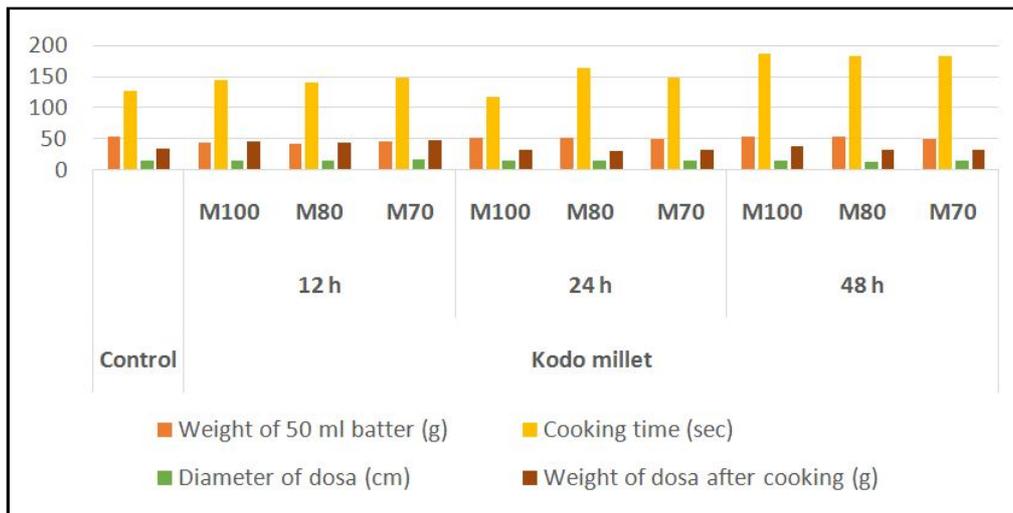


Figure 3: Physical parameters of kodo millet dosa.

Figure 3 shows the physical parameters of kodo millet dosa prepared with instant kodo millet dosa mix. The physical properties such as weight of batter, diameter of dosa, cooking time and weight of dosa were observed in comparison with control dosa. The results revealed that the weight of 50 ml dosa batter (54 g) prepared with 100 per cent and 80 per cent kodo millet with 48 h of fermentation was similar to the control dosa (54 g), whereas, the other treatments for 12 and 24 h were having less weight than the control dosa ranging from 42-52 g. The millet dosa prepared with 24 h 100 per cent kodo millet took 117 sec to cook than the control dosa (126 sec) which was lower than all

other millet dosa treatments. In comparison to the diameter of the control dosa (16 cm), the kodo millet dosa made with 100 per cent, 80 per cent and 70 per cent kodo millet with 12 h fermentation had a diameter of 16, 16 and 17 cm to cook. All dosa treatments prepared with 24 h fermentation time were 15 cm. For 48 h, the dosa prepared with 100 per cent, 80 per cent and 70 per cent of kodo millet were 16, 14 and 15 cm in diameter. The weight of cooked dosa ranged from 31 to 48 g, the highest being in 100 per cent kodo millet dosa made after 48 h of fermentation whereas, the lowest being in 80 per cent millet dosa made with grains fermented for 24 h.

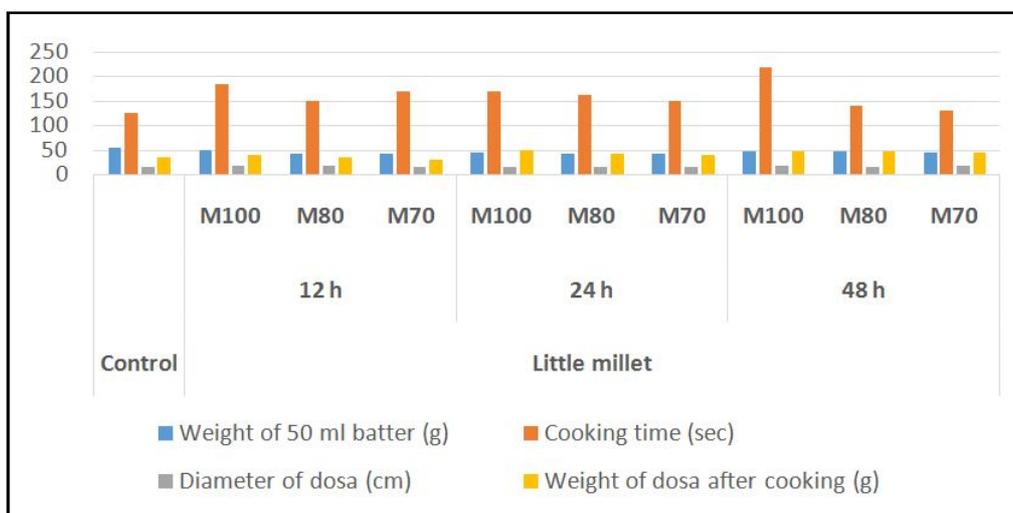


Figure 4: Physical parameters of little millet dosa.

Figure 4 depicts the physical parameters of little millet dosa prepared with instant little millet dosa, the weight of the control dosa batter (50 ml) was 54 g whereas, the little millet dosa batter had a lower range of weight from 40 to 49 g for different fermentation time and proportion. The control dosa took less time to cook (126 sec) as compared to the other millet dosa which ranged from 130 to 220 sec, the highest being in 100 per cent little millet dosa with 48 h of fermentation and the lowest being in 70 per cent little millet dosa

with 48 h of fermentation. The diameter of the control dosa was 16 cm. The dosa prepared with 12 h fermented grains (100, 80 and 70 per cent) was 18, 18 and 14 cm, respectively. Similarly, for 24 h fermentation time, the dosa were 16, 16 and 15 cm. After cooking, the weight of the control dosa was 35 g which was lower than the other millet dosa treatments, the highest (50 g) being in 100 per cent little millet dosa with 24 h of fermentation and the lowest (34 g) being in 80 per cent little millet dosa with 12 h of fermentation.

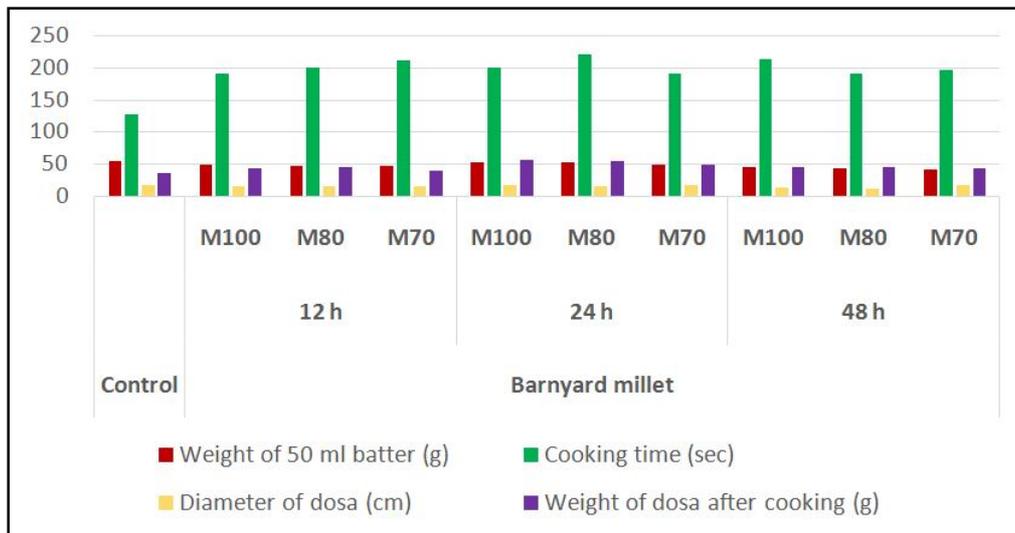


Figure 5: Physical parameters of barnyard millet dosa.

Figure 5 depicts the physical parameters of dosa prepared with instant dosa mix of barnyard millet. The weight of the batter of the control dosa was 54 g which was higher than any other barnyard millet dosa which ranged from 41 to 48 g in weight. The cooking time of the control dosa mix (126 sec) was the lowest among all dosa categories of barnyard millet. The highest time (220 sec) was taken by 80 per cent barnyard dosa with 24 h of fermentation whereas, the

lowest time (190 sec) was taken by 100, 70 and 80 per cent of barnyard dosa prepared with 12, 24 and 48 h fermented grains, respectively. The dosa prepared with 100 per cent and 70 per cent barnyard millet with a fermentation time of 24 h had an equal diameter of 16 cm whereas, the other treatments were having lesser diameter than the control dosa. After cooking, the millet dosa had higher weights ranging from 40 g (70% for 12 h) to 56 g (100% for 24 h).

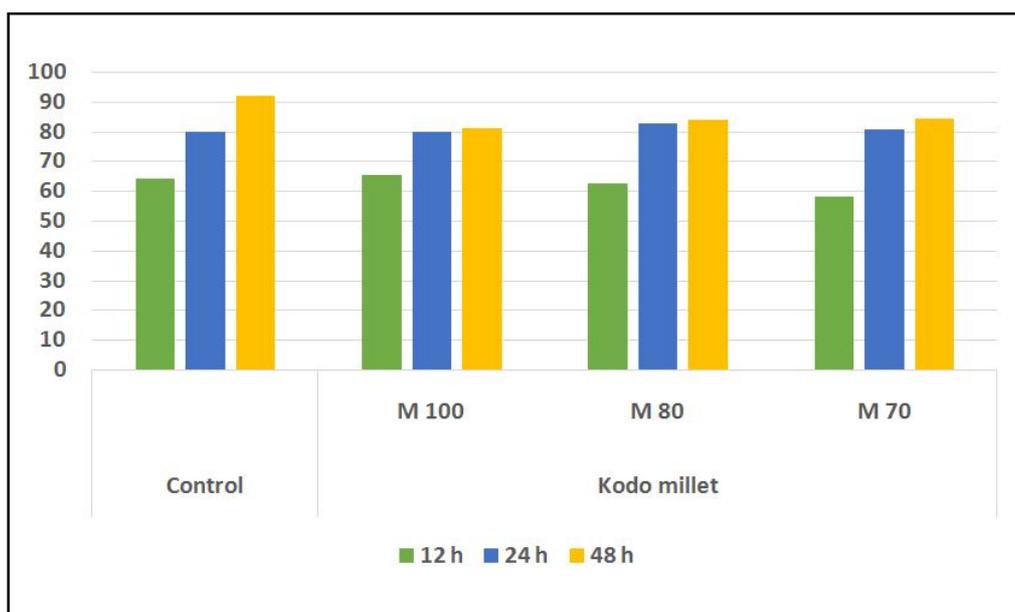


Figure 6: Acceptability index of kodo millet dosa.

3.3 Sensory evaluation of millet dosa prepared with instant millet dosa mixes

Figure 6 presents the acceptability indices of different dosa prepared with 100, 80 and 70 per cent kodo millet incorporation under the fermentation period of 12, 24 and 48 h. The sensory evaluation revealed that the sensory acceptability scores were increasing on increasing the fermentation period among all the categories of dosa mix (100, 80 and 70%) along with the control dosa. The control dosa scored highest (91.95%) for the 48 h of fermentation, followed by 24 h (79.97%) and 12 h (63.99%). Similarly, the 100 per cent kodo millet dosa scored 80.86, 79.97 and 65.43 per cent for 48, 24 and 12

h respectively. However, the sensory scores of kodo millet dosa prepared with 80 per cent (83.74, 82.49, 62.55%) and 70 per cent (84.16, 80.80 and 58.23%) for 48, 24 and 12 h respectively, were lower than the 48 h fermented control dosa (91.95%), but it was higher than the scores of 100 per cent kodo millet incorporated dosa which shows that the acceptability was good at a lower per centage of incorporation (70%) and acceptability can be increased by increasing the fermentation time upto 48 h. Among all the treatments, kodo millet dosa prepared with 80 per cent of kodo millet incorporation with 24 h of fermentation was found to be best accepted and selected for further analysis.

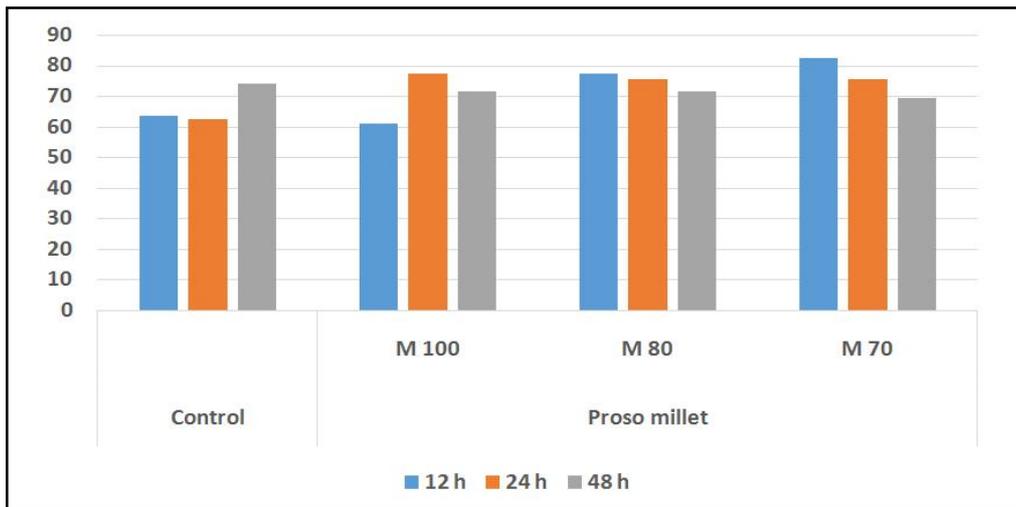


Figure 7: Acceptability index of proso millet dosa mix.

Figure 7 presents the acceptability indices of different dosa prepared with 100, 80 and 70 per cent of proso millet incorporation under the fermentation period of 12, 24 and 48 h. The control dosa scored highest (74.34%) for the 48 h of fermentation, followed by 24 h (62.7%) and 12 h (63.90%). Similarly, the 100 per cent proso millet dosa scored 71.96, 77.58 and 61.30 per cent for 48, 24 and 12 h, respectively. However, the sensory scores of proso millet dosa prepared with 80 per cent (71.69, 75.63 and 77.5%) and 70 per cent (69.58, 75.63 and 82.40%) were higher than the control dosa scores for 49, 24

and 12 h of fermentation. The sensory results revealed that the acceptability of proso millet dosa was better than the control dosa but it was more acceptable at lower incorporation levels such as 80 and 70 per cent. The increase in the fermentation period was causing decreasing in the sensory scores as the dosa with only 12 h of fermentation scored higher among their category as well as the control dosa. Among all the dosa mixes, the dosa mix prepared with 100 per cent incorporation within 24 h of fermentation was found better than the control dosa and selected as the best formulation for further analysis.

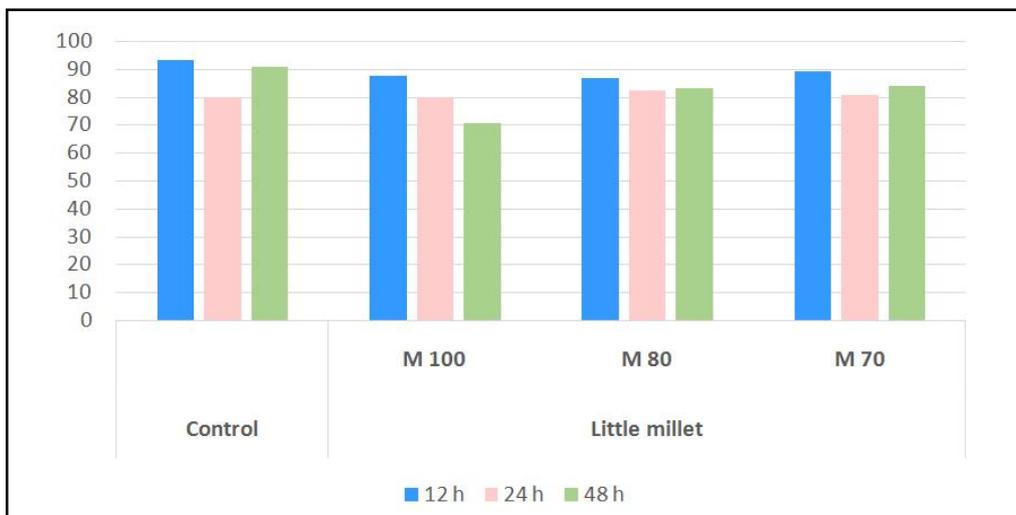


Figure 8: Acceptability index of little millet dosa.

Figure 8 presents the acceptability indices of different dosa prepared with 100, 80 and 70 per cent of little millet incorporation under the fermentation period of 12, 24 and 48 h. The control dosa scored highest (92.96%) for the 12 h fermentation, followed by 48 h (91.15%) and 24 h (79.97%). Similarly, the 100 per cent little millet dosa scored 87.96, 79.97 and 80.86 per cent for 24, 12 and 48 h respectively. However, the sensory scores of little millet dosa prepared with 80 per cent (87.22, 82.49 and 83.54%) and 70 per cent (89.63, 80.81 and 84.16%) for 12, 24 and 48 h were lower than the control dosa scores (92.96 and 91.15%) for 12 and 48 h of fermentation. The sensory results revealed that the acceptability of little millet dosa was better than the control dosa at lower incorporation levels such as 80 and 70 per cent and 24 h of fermentation time. The increase in the fermentation period was causing decreasing in the sensory scores under each category of incorporation (100, 80 and 70%). Among all dosa mixes, the dosa mix prepared with 70 per cent incorporation within 12 h of fermentation was found better than the control dosa and selected as the best formulation for further analysis.

Figure 9 presents the acceptability indices of different dosa prepared with 100, 80 and 70 per cent of barnyard millet incorporation under the fermentation period of 12, 24 and 48 h. The sensory evaluation acceptability scores were decreasing on increasing the fermentation period among all the categories of dosa mix (100, 80 and 70%) along with the control dosa. The control dosa scores for the 48 h (53.9%), 24 h (55.70%) and 12 h (68.30%) were lower than all other categories of barnyard millet incorporated dosa, respectively. Similarly, the barnyard millet dosa scores showed decreasing pattern for 12, 24 and 48 h fermentation periods as per their scores for 100 per cent (83, 67.8 and 57.4%), 80 per cent (83.9, 66.3 and 58.3%) and 70 per cent (91.9, 64.1 and 58.1%) millet incorporation. At a lower percentage of millet incorporation, there was an increase in the acceptability scores of the barnyard millet incorporated dosa mix. Among all the treatments barnyard millet dosa prepared with 70 per cent of barnyard millet incorporation with only 12 h of fermentation was found best accepted by the sensory panel as it scored highest (91.9%) which is quite higher than the control dosa revealed that the sensory.

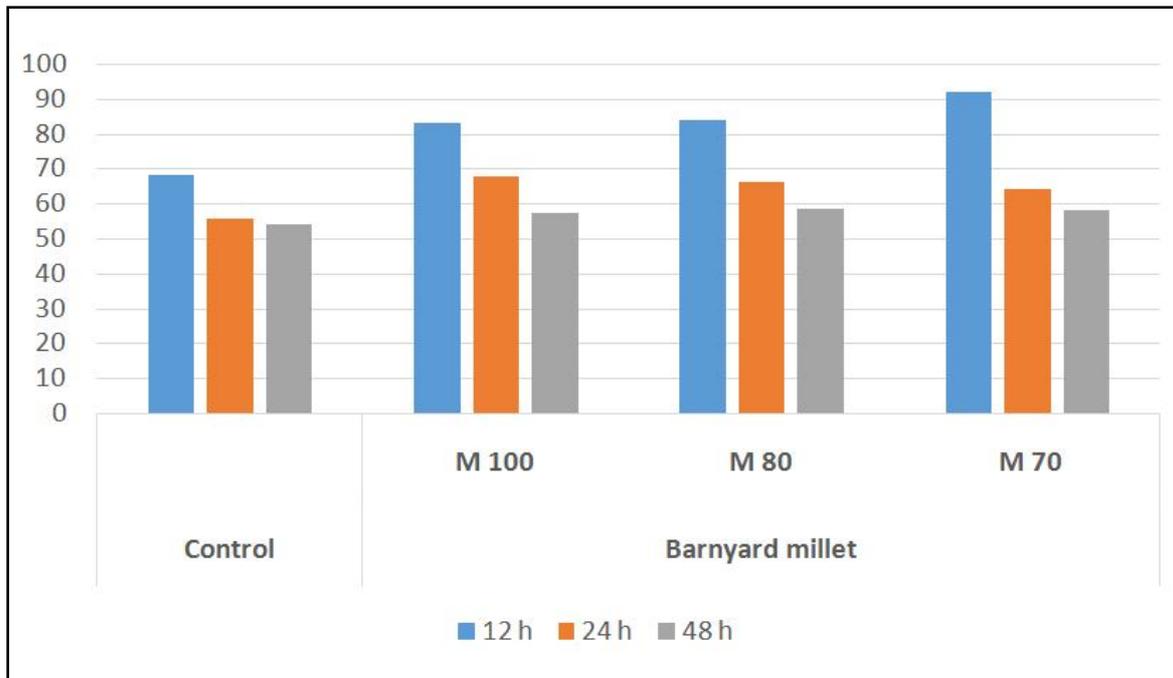


Figure 9: Acceptability index of barnyard millet dosa mix.

Based on the sensory evaluation of dosa prepared with different instant dosa mixes, the best-selected formulations are presented in Table 3. The formulation with 80 per cent kodo millet and little millet with 24 h of fermentation were selected best whereas, for

barnyard millet instant dosa mix, only 70% formulation with 12 h of fermentation was selected. For the proso millet instant dosa mix, 100% formulation with 24 h of fermentation was selected best based on the sensory acceptability scores.

Table 3: Standardized formulations of instant millet-based dosa mixes

Minor millet	Millet proportions	Duration of fermentation
Kodo millet	80%	24 h
Proso millet	100%	24 h
Little millet	80%	24 h
Barnyard millet	70%	12 h



Figure 10: Dosa prepared from control and kodo millet instant dosa mixes.



Figure 11: Dosa prepared from control and proso millet instant dosa mixes.



Figure 12: Dosa prepared from control and little millet instant dosa mixes.



Figure 13: Dosa prepared from control and barnyard millet instant dosa mixes.

3.4 Nutritional composition of instant millet dosa mixes

The nutritional composition of selected dosa mixes is presented in Table 4. The moisture content of millet dosa mixes varied from 7.14% and 8.12%, with no significant differences observed between the control and experimental samples. The highest moisture content was present in the kodo millet dosa mix (8.12%), followed by barnyard (8.01%) and proso millet (7.98%) dosa mix which were similar to the moisture level of the control dosa mix (7.78%), but little millet (7.14%) dosa mix had significantly lower moisture than control dosa mix. The fat content of the instant dosa mixes ranged from 1.96 to 5.82 per cent and was significantly different at the 1% level. The significantly higher kodo millet (5.82%) dosa mix as compared to the control dosamix which was statistically similar to the proso millet dosa mix (1.96%). The protein content of different millet dosa mixes ranged from 8.61 to 16.36% whereas, the control dosa mix had significantly higher (at 1% level) protein content (17.21%). The proso millet dosa mix had the highest protein (16.39%) after the control dosa mix however the little millet dosa mix had the lowest protein (8.61%). The crude fiber content of the different dosa mixes varied from 0.68 per cent in little millet to 1.82 per cent

in the kodo millet dosa mix which was significantly similar (at 1% level) to the control dosa mix (1.75%). The ash content of different millet dosa mixes ranged from 4.33 per cent in the proso millet dosa mix, the lowest among the millet dosa mixes, but similar to the control dosa mix (4.19%). The highest ash content was found in the barnyard (6.72%) and kodo millet (6.49%) and ash values were significantly higher at 1% level. Significantly higher total carbohydrate content was found in little millet (73.70%), followed by kodo millet (70.96%) dosa mix as compared to the control dosa mix (68.67%) which was significantly similar to the proso (69.34%) and barnyard (69.53%) millet dosa mix. In a similar pattern, the available carbohydrates of different millet dosa mixes little (73.02%), kodo (69.14%), proso (67.35%) and barnyard (67.98%) millet dosa mixes were significantly higher than the control dosa mix. The control dosa mix contained 356 kcal, which was significantly similar to kodo millet (363 kcal) but the proso (353 kcal), little (364 kcal) and barnyard millet (360 kcal) dosa mixes were significantly higher for their energy content as compared to control dosa mix and the values were significantly different at 1% level. The nutritional composition of millet dosa mixes is presented below.

Table 4: Nutritional composition of millet dosa mixes

Dosamix	Moisture (%)	Fat (%)	Protein (%)	Crude fiber (%)	Ash (%)	Total carbohydrate (%)
Control	7.78 ± 0.31 ^{ab}	2.14 ± 0.06 ^d	17.21 ± 0.37 ^a	1.75 ± 0.04 ^b	4.19 ± 0.10 ^c	68.67 ± 0.31 ^c
Kodo millet	8.12 ± 0.79 ^a	5.82 ± 0.10 ^a	8.61 ± 0.17 ^e	1.82 ± 0.02 ^b	6.49 ± 0.14 ^a	70.96 ± 0.55 ^b
Proso millet	7.98 ± 0.56 ^{ab}	1.96 ± 0.07 ^d	16.39 ± 0.09 ^b	1.99 ± 0.06 ^a	4.33 ± 0.30 ^c	69.34 ± 0.84 ^c
Little millet	7.14 ± 0.02 ^b	3.70 ± 0.25 ^c	9.63 ± 0.02 ^d	0.68 ± 0.04 ^d	5.84 ± 0.30 ^b	73.70 ± 0.30 ^a
Barnyard millet	8.01 ± 0.13 ^{ab}	5.06 ± 0.06 ^b	10.68 ± 0.04 ^c	1.55 ± 0.05 ^c	6.72 ± 0.10 ^a	69.53 ± 0.31 ^c
F-Value	2.214	518.350	1362.413	465.915	97.089	46.849
SEM	0.26	0.08	0.11	0.03	0.12	0.30
CD	NS	0.30**	0.42**	0.10**	0.48**	1.20**

SEM-Standard error mean, CD-Critical difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$).

Table 5: Antioxidant and mineral composition of millet dosa mixes

Dosa mix	Total phenols concentration (mg GAE/100 g)	Tannins (mg TAE/100 g)	Antioxidants (% DPPH)	Minerals (mg/100 g)		
				Iron (mg/100 g)	Zinc (mg/100 g)	Calcium + Magnesium (mg/100 g)
Control	1.03 ± 0.01 ^c	0.27 ± 0.01 ^c	12.57 ± 0.03 ^d	7.25 ± 0.10 ^c	3.54 ± 0.10 ^d	1013.33 ± 7.64 ^e
Kodo millet	1.48 ± 0.05 ^c	0.35 ± 0.02 ^b	31.36 ± 0.70 ^a	13.77 ± 0.08 ^a	6.95 ± 0.11 ^a	2474.33 ± 4.04 ^a
Proso millet	2.01 ± 0.05 ^b	0.20 ± 0.01 ^d	19.22 ± 0.20 ^c	10.18 ± 0.06 ^b	6.88 ± 0.09 ^a	1632.67 ± 2.52 ^d
Little millet	3.27 ± 0.39 ^a	0.40 ± 0.04 ^a	18.50 ± 0.55 ^c	6.61 ± 0.12 ^d	4.44 ± 0.21 ^b	1773.33 ± 7.64 ^c
Barnyard millet	1.82 ± 0.28 ^{bc}	0.37 ± 0.01 ^{ab}	27.60 ± 1.00 ^b	5.66 ± 0.08 ^c	4.07 ± 0.16 ^c	2210.00 ± 5.00 ^b
F-Value	44.59	46.25	465.83	3985.79	404.49	28940.39
SEM	0.13	0.012	0.35	0.05	0.08	3.31
CD	0.50**	0.046**	1.37**	0.20**	0.31**	13.00**

SEM-Standard error mean, CD-Critical difference, NS-non-significant, *Significant at 5%, **Significant at 1%. Values with a different superscript in the same column are significantly different ($p \leq 0.05$). GAE-Gallic acid equivalent, TAE- Tannic acid equivalent, DPPH- 2,2-diphenyl-1-picryl hydrazyl

3.5 Phytochemical and mineral composition of instant millet-based dosa mixes

The phytochemical composition of different instant millet dosa mixes is given in Table 5. The little millet dosa mix (3.27 mg GAE/100 g) had the highest total phenolics, followed by proso millet (2.01 mg GAE/100 g) and the lowest was found in the control dosa mix (1.03 mg GAE/100 g). The tannin content of millet-based dosa mixes was significantly higher than the control dosa mix (0.27 mg TAE/100 g). Among millet dosa mixes, little millet dosa mix had the highest tannin content of 0.34 mg TAE per 100 g, followed by barnyard millet (0.37 mg TAE/100 g) and kodo millet (0.35 mg TAE/100 g). The total antioxidant activity (DPPH %) of millet-based dosa mixes was significantly higher than the control group. The highest antioxidant activity was recorded in kodo millet dosa (31.36%), while the lowest was observed in the control sample (12.57%).

The minerals content analysis of dosa mixes revealed that the iron, zinc, calcium and magnesium content of all the millet dosa mixes were significantly different than the control dosa mix. The iron content of the kodo millet dosa was found highest (13.77 mg), followed by proso millet (10 mg). The little millet and barnyard millet dosa mix had 6.61 mg and 5.66 mg which was significantly lower than the control dosa mix (7.25 mg) per 100 g of dosa mix. Similarly, the zinc content of the kodo millet was highest (6.95 mg), followed by proso (6.88 mg), little (4.44 mg) and barnyard millet (4.07 mg). The phosphorus content of the instant millet dosa mixes was higher than the control dosa mix but not significant at a 5 per cent level. The calcium and magnesium content of the instant dosa millet mix was significantly different than the control dosa mix (1013.33 mg), the highest content was in kodo millet (2474.33 mg), followed by barnyard (2210 mg), little millet (1773.37 mg) and proso millet (1632.67 mg).

3.6 Functional properties of instant millet-based dosa mixes

The functional properties such as water solubility, swelling power, water holding capacity, water absorption capacity, oil absorption capacity, water retention capacity and hydrophilic-lipophilic index of different instant millet dosa mixes were analyzed and presented in Table 6. The higher water solubility index of kodo (8.55%), followed by proso (7.23%) and little millet (7.32%) were significantly similar and different from the control dosa mix (3.25%) which was similar to barnyard millet (2.4%) with very low WSI. The swelling power of the control dosa mix (313.65%) was significantly similar to kodo millet (327.62%) and little millet (286.59%) whereas, proso millet (252.58%) had significantly lower swelling power. Water holding capacity of little millet (127.33%), barnyard millet (123.83%) and kodo millet (119.36%) were higher than the control dosa mix (105.73%) which was on par with the proso millet dosa mix (109.31%). The water absorption capacity of the control (1.15 g/ml) and kodo millet (1.20 g/ml) were significantly different from each other whereas, the other millet dosa mix was on par with the kodo and control dosa mix. The oil retention capacity of little millet dosa (0.49 g/ml) was significantly higher than the control (0.39 g/ml) whereas, the other millet dosa mix were on par with the control (0.39) and little millet dosa mix (0.49 g/ml). The water retention capacity of kodo millet (0.51 g/ml), little millet (0.47 g/ml) followed by proso millet (0.32 g/ml) was significantly higher than the control (0.14 g/ml) and barnyard millet (0.19 g/ml) dosa mix. The hydrophilic-lipophilic index of little millet (0.95%) and proso millet (0.66%)

were significantly higher than the control (0.39%), kodo (0.46%) and barnyard millet (0.48%) dosa mix that was similar to each other.

3.7 Storage parameters of instant dosa mix

Shelf-life indicator storage parameters of the millet dosa mix were studied. The moisture level of kodo millet instant dosa mix ranged from 8.65 per cent to 11.43 per cent, the proso millet dosa mix ranged from 9.08 per cent to 11.25 per cent, little millet dosa mix ranged from 7.81 per cent to 9.98 per cent and the barnyard millet dosa mix ranged from 8.66 per cent to 11.18 per cent during the storage period of 0th to 120th day. The total bacterial count and total mold count of different dosa mixes increased during the storage period.

According to the Indian Standard Specification for dosa mix (ISI:10622) given in 1983, the moisture requirement for millet dosa mix is a maximum of 12 per cent by mass for ready-to-cook mixes. In the present study, the moisture content of all the dosa mixes was within the range of standards as moisture per centage ranged from (8-11.5%) approximately. Based on the moisture and microbial content, the shelf-life of the kodo millet instant dosa mix was 30 days, the proso millet instant dosa mix was 60 days, the little millet dosa mix was 120 days and the barnyard millet dosa mix was 60 days long from the day of production and packaging of the product. Among all the dosa mixes little millet had the highest shelf-life of 120 days as there was no mold growth during the storage period of 120 days which might be because of the lower moisture content of 9.98 per cent as compared to the other millet dosa mix.

4. Discussion

This study standardized four dosa mixes with kodo (80%), proso (100%), little (80%) and barnyard millet (70%) with 24, 24, 24 and 12 h of the fermentation period. Further analysis of the nutritional and phytochemical constituents of the dosa mix revealed that all the nutrients were significantly different from each other. The proso millet dosa had the highest protein and crude fiber, little millet had the highest total and available carbohydrates, barnyard millet had the highest ash whereas, kodo millet dosa provided the highest energy. As in the present study, the millet grains were soaked and fermented before drying and milling, which helps in the improvement of the functional properties of millet flours which ultimately enhances the sensory properties of dosa mixes which results in the possible incorporation of millets at higher per centages than the previous researches.

In the present study, all the selected dosa mixes contain more than 50 per cent of millet incorporation which can be categorized as 'millet-based' instant dosa mixes. The developed instant dosa mixes had good physical and nutritional properties. Similar findings were also reported by previous research where the impact of barnyard millet flour incorporation on sensory characteristics and shelf-life of instant dosa mix was studied by Karakannavar *et al.* (2021) and instant barnyard dosamixes with 50 per cent of barnyard millet flour were found acceptable. However, in the present study, 70 per cent of barnyard millet flour was acceptable with a good sensory acceptability score. 50 per cent incorporated barnyard millet dosa had 9.50 per cent moisture, 12.67 per cent protein, 2.64 per cent fat, 1.81 per cent crude fiber, 2.57 per cent ash, 72.62 per cent carbohydrates, 4.93 mg of iron, 2.21 mg of zinc and 23.94 mg of calcium per 100 g of barnyard dosa mix which was having the shelf-life of four and half months when stored in laminated pouches at

ambient temperature. Whereas, in the present study, the barnyard millet dosa had less protein (10.68%), more fat (5.06%), ash (6.72%), crude fiber (1.55%) and on par carbohydrate (73.70%) per 100 g of dosa mix.

Similarly, a dosa breakfast mix was developed by Mounika *et al.* (2021) by incorporating raw foxtail millet at different levels (25%, 35%, 40% and 50%). Dosa prepared by incorporating foxtail millet recorded the protein (14-15%), fat (5-9%), ash content (2-3%) and crude fiber (2-4%) content per 100 g of dosa mix which was higher than the traditional dosa mix. The study also reported that during the different processing steps involved in the preparation of dosa, fermentation decreased the tannin content when millets were incorporated into the dosa mix.

Roopa *et al.* (2017) concluded that the millet-based instant dosa mix could be considered beneficial from both nutritional and sensory points of view. The formulation of millet based dosa mix at 30% rice, 40 per cent little millet, 20 per cent black gram and 10 per cent lentil flour was accepted as the best formulation whereas, in the present study, the little millet incorporation was possible up to 80 per cent in instant dosa mixes after the 24 h fermentation treatment to the little millet grains. Vindhya and Roobhadevi (2014) reported that a dosa mix with only 20 per cent kodo millet incorporation was best accepted due to the darker color and grainy feel of kodo millet whereas, in the present study, 80 per cent kodo millet incorporation was found best because the grains were soaked in water and treated for 24 h of fermentation. Similar results were also reported by Vijayalaxmi *et al.*, 2020 who developed instant kodo dosa mix with kodo millet flours with parboiled rice at different incorporation levels at 25, 50, 75 and 100 per cent and control 100 per cent with rice flour. The developed product was acceptable for up to 75 per cent kodo flour incorporation along with 6 months of shelf-life. Moisture (11.53 %), ash (3.49 g), crude fiber (1.733 g), calcium (53.83 mg) and iron (5.62 g) contents were significantly high in kodo millet dosa mix having 6 months shelf-life. In the present study, the little millet instant dosa mix was found with highest shelf-life of 120 days as there was no mold growth during the storage period.

5. Conclusion

As millets have different physical-functional properties than cereals and legumes, they behave differently during processing and product development. Therefore, the present study tried to standardize different millet instant dosa mixes with pre-treatments which will help to reduce antinutrients and enhance the physical and functional properties of millet grains. The millet grains were subjected to soaking and fermentation before mix preparation. This study standardized four dosa mixes with kodo (80%), proso (100%), little (80%) and barnyard millet (70%) with 24, 24, 24 and 12 h of the fermentation period. The dosa prepared with instant dosa mixes was accepted with good sensory scores, nutritional and phytonutrient profiles. These innovative products exhibit greater commercial potential as these products have rich nutritional composition, better shelf life and improved functional properties. The present developed products can be taken in combination with any pulses-based recipes to meet daily protein requirements however millet-based products were loaded with considerable amounts of fiber and phytochemicals which provide prominent health benefits and act as protection against various lifestyle diseases. Development of such kind of millet-based instant breakfast mixes under the fermented category has

significant market demand whereas, the present market is overshadowed by products with lower millet content. These value-added fermented millet-based instant dosa mixes can be included in day-to-day breakfast menus to save consumers time without compromising the nutrition of the meal.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

- AOAC (1990).** Official methods of Analysis. Association of Official Analytical Chemists. 15th Edition. Arlington Virginia, USA.
- AOAC (2005).** Official methods of Analysis. Association of Official Analysis Chemists International. 18th Edition. Arlington VA, USA.
- AOAC (2006).** Official methods of Analysis. Association of Official Analytical Chemists. 18th Edition. Washington, DC.
- AOAC (2010).** Official methods of Analysis. Association of Official Analytical Chemists. 18th Edition. Washington, DC.
- AOAC (2012).** Official methods of Analysis. Association of Official Analysis Chemists International, 19th Edition. Gaithers burg, Maryland.
- Arora, L.; Kaur, S. and Aggarwal, R. (2022).** Minor millets: Abandoned grains with promising prospects. *Journal of Food Science and Nutrition*, **8**:134.
- Awoyale, W.; Oyedele, H. and Maziya-Dixon, B. (2020).** The functional and pasting properties of unripe plantain flour, and the sensory attributes of the cooked paste (amala) as affected by packaging materials and storage periods. *Cogent Food and Agriculture*, **6**(1):1823595.
- Balli, D.; Cecchi, L.; Pieraccini, G.; Venturi, M.; Galli, V.; Reggio, M.; Di Gioia, D.; Furlanetto, S.; Orlandini, S. and Innocenti, M. (2023).** Millet fermented by different combinations of yeasts and Lactobacilli: Effects on phenolic composition, starch, mineral content and prebiotic activity. *Foods*, **12**:748.
- Bhag, M.S.; Padulosi. and Bala, R.S. (2010).** Minor millets in South Asia: Learnings from IFAD-NUS Project in India and Nepal. Biodiversity International, Maccaresse, Rome, Italy and the M.S. Swaminathan Research Foundation, Chennai, India: pp:185.
- Deshpande, S.S.; Mohapatra, D.; Tripathi, M.K. and Sadvatha, R.H. (2015).** Kodomillet-nutritional value and utilization in Indian foods. *Journal of Grain processing and storage*. **2**(2):16-23.
- Indian Standard Specification for Dosa Mix (1983).** Indian Standards Institute, New Delhi.
- Jain, P.V. and Shekhar, A. (2021).** 'Six-Mix' Multi-Millet dosa mix and its shelf-life. *International Journal of Creative Research Thoughts (IJCRT)*. **9**(7):b456-b464.
- Karakannavar; Sarojani; Nayak; Geeta; Madhushri, Y. and Hilli, S. (2021).** Development and evaluation of barnyard millet instant dosa mix. *International Journal of Agricultural Sciences*, **17**:197-203
- Mahalakshmi, K. and Sarojini, K. (2023).** Development and standardization of instant browntop millet dosa mix. *The Pharma Innovation.*, **Sp.12**(A):878-880.

- Maxwell Beugre, G.A.; Yapo, B.M.; Blei, S.H. and Gnakri, D.(2014). Effect of fermentation time on the physicochemical properties of maize flour. *International Journal of Research Studies in Biosciences*, **2**:30-38.
- Meilgaard, M.; Civile, G.V. and Carr, B.T. (1999). *Sensory evaluation technique*. 3rd Edition, CRCpress, Boca Raton.
- Mesias, M. and Morales, F.J.(2017). Effect of different flours on the formation of hydroxymethyl furfural, furfural and dicarbonyl compounds in heated glucose/flour systems. *Foods*, **6**(2):14.
- Mounika, P.; Gnanashree, G.; Sangeetha, P.; Tejaswini, A. and Samreen. 2021. Effect of incorporation of foxtail millet for preparation of dosa breakfast mix and comparison with the traditional dosa mix. *Biological Forum : An International Journal*, **13**(4):501-507.
- Njintang, Y.N.; Mbofung, C. M. F.; Moates, G.K.; Parker, M.L.; Craig, F.; Smith, A. C. and Waldron, W. K. (2007). Functional properties of five varieties of taro flour, and relationship to creep recovery and sensory characteristics of Achu (taro-based paste). *Journal of Food Engineering*, **82**(2):114-12. Copyright@2021: Hind Agri-Horticultural Society
- Rahul, B.; Bharti.; Pankaj, D.; Samir, B.; Sarita, D. and Ankita. (2024). Comprehensive analysis of millets in India: Area, production, cost of production and export statistics. *Current Agriculture Research Journal*, **12**(3):1181-1192.
- Roopa, S.S.; Dwivedi.; Hemraj. and Rana, G.K. (2017). Development and physical, nutritional and sensory evaluation of instant dosa mix. *Techno Fame: A Journal of Multidisciplinary Advance Research*. **1**:109-113.
- Selvaraj, R.J.; Kandsamy, K. and Dorathy, P. (2018). Development of instant dosa batter mix with enhanced nutritive value and its storage study. *Indian Journal of Research in Food Science and Nutrition*. **5**(2):70-73.
- Shivanshu, G.; Pooja, N. and Himanshu, P. (2024). History and origin of millets in India. *Krishi Science: eMagazine for Agricultural Sciences*, **05**(04):45-48.
- Tambekar, D.H.; Murhekar, S.M.; Dhanorkar, D.V.; Gulhane, P.B. and Dudhane, M.N. (2009). Quality and safety of street vended fruit juices: A case study of Amravaticity, India. *Journal of Applied Biosciences*. **14**:782-787.
- Thirumangaimannan, G. and Gurumurthy, K. (2013). A study on the fermentation pattern of common millets in Koozh preparation: A traditional South Indian food. *Indian Journal of Traditional Knowledge* **12**(3):512-517
- Vidhya A.M. and Roobhadevi, M. (2014). Formulation and shelf life evaluation of kodomillet incorporated ready-to-cookmixes. *Indian Journal of Research in Food Science and Nutrition*, **1**(1):27-31.
- Vijayalaxmi, K.G.; Jayalaxmi, B. and Vanishri, K.U. (2020). A study on the development of instant kododosa mix and evaluation of its nutritional composition and shelf-life. *International Journal of Current Microbiology and Applied Sciences*. **9**(12):286-295.

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