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Effect of particle size of ragi flour on physico-chemical and sensory profile of *ragi mudde*

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Ragi mudde is a traditional food made with ragi (finger millet) flour. It is a major source of carbohydrates, calcium, iron, protein and well-balanced amino acids and is a staple diet in rural parts of South India. The consistency of *ragi mudde* depends on the particle size of its flour and water uptake during cooking. Ragi flour (RF) particle size was determined by a particle size analyzer. The physical properties such as bulk density of RF and water uptake during cooking were also measured. Traditionally cooked *ragi mudde* was characterized for color and texture by sensory and instrumental analysis. The coarseness or fineness of the RF was found to have a tremendous effect on the physical and sensory profile of *ragi mudde*, such as hardness, stickiness, cooking quality, color and texture. Ragi flour with different particle sizes, viz., 150 (S1), 300 (S2), 450 (S3), 600 (S4), and 750 (S5) µm were used in the preparation of *ragi mudde*. Color values, expressed as L*, a* and b*, showed significant differences among the samples. Texture profile analysis (TPA) of the samples showed a positive correlation between hardness and stickiness. The results of quantitative descriptive analysis (QDA) revealed that samples S4 and S5 scored high for the overall quality. Considering the above parameters, RF with particle size 600-750 µm suits best and is ideal for the preparation of *ragi mudde*.

Keywords: Finger millet, Particle size, Ragi flour, *Ragi mudde*, Sensory

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Ragi (*Eleusine coracana*) is a popular millet crop and is a major food source in the diet of the rural population of Karnataka and other parts of South India[1]. This low-cost small millet grain is unique among the minor cereals and is superior to wheat and rice[2]. Millets are gluten-free and highly nutritious with good nutraceutical properties[3]. Ragi contains a large proportion of calcium, total carbohydrates (65-67%), with a low glycemic index, protein, fat, fiber, and ash along with tannins (0.61%), polyphenols, and trypsin inhibitory factors[4,5]. Ragi has well-balanced amino acid composition and is considered as a good source of lysine, cystine and methionine[6]. Although this millet crop is one of the staple foods for a larger segment of South Indian and African populace, its consumption is limited to only in the form of flour-based products.

Rapid urbanization and present family structures lead to changes in lifestyles and have great influence on the eating patterns. A huge shift from consumption of coarse grains to polished cereals has resulted in availability of reduced bioactive components and fibers in the diet, which in turn is associated with various non-communicable diseases like diabetes mellitus, hypertension, obesity, etc., which could be prevented by day to day consumption of complex carbohydrates in the diet[7]. The regular intake of ragi-based foods offers anti-ulcerative characteristics apart from having a huge health potential against various chronic diseases such as hypocholesterolemic, hypoglycemic, arthritis, cognition disorder and cancer[8]. Ragi seed coat contains various polyphenolic compounds which have been reported to exhibit antioxidant, anti-inflammatory, antimicrobial, antiviral, and anticancer activities[9,10]. Ragi has a low-glycemic index and is rich in nutrients like calcium, iron, and dietary fiber. Hence, ragi is considered to be an ideal food for diabetic patients due to its slowly digestible starch in the body and is also considered as a wonder food crop for people in all walks of life.

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Ragi is invariably pulverized into flour and is used to prepare traditional foods like unleavened pancakes (*roti*), thin porridge (*ambali*) and stiff porridge or dumpling (*ragi mudde*/ragi ball), which are the most popular breakfast foods in the rural areas of Karnataka. Ragi flour is also incorporated with different proportions to wheat flour in the baking of biscuits, bread and snacks[11,12]. *Ragi mudde* commonly called '*mudde*' is a traditional food of South Karnataka. It is a steamed dumpling prepared traditionally, relished for its soft and smooth texture and is commonly consumed with sambar or curry.

There are no systematic studies on *ragi mudde* and its quality characteristics. Proper documentation is important not only to authenticate the technology and to standardize the processing parameters such as formulation, method of preparation, types of equipment, and quality characteristics for successful commercialization. It is reported that fineness or coarseness of rice flour has found tremendously affect the physical and sensory characteristics of Sel – roti[13]. This is the first report to study the physical and sensory characteristics of *ragi mudde* prepared with different RF fractions. The information on the quality parameters of RF is desirable to identify suitable particle sizes for the preparation of *ragi mudde*. Hence, this study was focused on determining the suitable particle size of RF in the preparation of *ragi mudde* with desirable physical and sensory qualities. The central food technological research institute (CFTRI), Mysuru, India launched a fully automated *ragi mudde* machine, which can produce mudde on a large scale with minimum time. This machine is suitable for large-scale production of *mudde* in restaurants, jails, industrial, defense canteens, etc.

Methodology

Plant material and chemicals

A popular ragi cultivar of Karnataka, Indaf-7, bulk procured from the Agricultural Research Station, Vishweshwaraiah Canal (VC) farm, Mandya, South Karnataka, was cleaned and the milling process of ragi was carried out in a conventional cereal plate mill (Madras mill Pvt. Ltd.).

Termamyl enzyme was purchased from Sigma-Aldrich chemical co., St. Louis Mo, USA, and all other chemicals were purchased from SD fine-chem Ltd., India.

Fractions of ragi flour

The Ragi Flour (RF) was analyzed for particle size distribution as per the Bureau of Indian Standards (BIS)[14]. The particle size of RF was categorized into three fractions, viz., fine (150, 300 µm), medium (450 µm) and coarse (600-750 µm). A set of sieves with clear openings of 150, 300, 450, 600 and 750 µm (BIS sieves) were used to collect different fractions. Milled RF was sieved manually. The RF retained and passed through in each sieve was collected and weighed for further studies.

Preparation of *ragi mudde*

Preparation of *ragi mudde* was carried out using different fractions of RF by the traditional method. A small quantity of RF was first mixed with cold water to form slurry. As this mixture boils, the remaining RF was added slowly and then cooked with continuous stirring to avoid any lumps formation, for about 15-20 min. When it starts thickening, the cooked RF was kneaded into dough and shaped into medium size balls.

Physico-chemical analysis

Proximate analysis

Different fractions of RF samples were analyzed for moisture, ash, fat, and protein as per AACC method[15]. Total carbohydrate content was calculated by the difference method. The soluble and insoluble dietary fiber contents were estimated as per the method of Asp *et al.*[16].

Bulk density

The bulk density of RF fractions was determined by filling the known weight of the sample in a measuring cylinder (250 mL). The volume difference of the sample was calculated and expressed as g/mL as density[17]. The average value of three replicates was reported.

Water uptake ratio

The water uptake ratio was determined by the amount of water required for the preparation of *mudde* using different flour fractions of ragi in 100 mL boiling water.

Color measurements of ragi mudde

The color of the *ragi mudde* samples was measured according to CIE L*, a*, b* color space system based on the tristimulus values using the Hunter lab color measuring system[18] (Labscan XE system, Reston, USA). The 'L' value represents the lightness or darkness. The 'a' value indicates the redness when positive and greenness when negative. The 'b' values are for the yellowness when it is positive and blueness when it is negative. Calculated ΔE indicates the magnitude of the total color difference. The average of three replicates for L*, a* and b* was reported.

Texture profile analysis of ragi mudde

Texture profile analysis (TPA) of ragi mudde was carried out by using a texture analyzer (LLOYD-LR-5K) under crosshead speed of 100 mm/min and compression -50% employing a 50 kg load cell conditions.

Ragi mudde prepared by using different fractions of RF were subjected to TPA and measured for parameters like hardness, cohesiveness, chewiness, springiness, gumminess, stiffness and adhesiveness[19]. The average of triplicate measurements was reported in Newton (N).

Sensory evaluation of *ragi mudde*

Sensory analysis of *ragi mudde* was carried out in two phases, namely ranking test and quantitative descriptive analysis. The preference ranking test was adopted as a preliminary step to select the best among the samples. The selected sample was used for further studies such as profiling. Descriptive analysis was chosen because the product required in-depth sensory testing to assess the quality of various attributes present in the mudde and to know whether the particle size of RF had any influence in the overall quality of *ragi mudde*.

Preference ranking test[20] was conducted with 25 panelists. The panel had both trained and semi-trained persons and the panelists were asked to rank the samples in the increasing order of intensity for the attributes color, texture, and taste. The panelists were suitably trained for the testing procedure and conditions. The samples were presented in random order and the panelists were asked to rearrange and rank the samples in the order of preference for overall quality (the most preferred sample gets the lowest rank-sum and the least preferred sample gets the highest rank-sum). The rank-sum of each sample was subjected to Friedman's test[21] for determining whether there was a significant difference between the samples. By using Kramer's rank-sum test[22], the superior and inferior samples were identified.

Quantitative descriptive analysis[23] was done for profiling the *ragi mudde* samples. An appropriate score card was formulated by a trained panel using the "Free choice profilng" method. The panel members were asked to describe the samples with as many spontaneous descriptive terms as possible. The common descriptors chosen by 1/3rd of the panel members were collated along with some impact of making descriptors for the score card preparation. The panel consisted of 20 members who were experienced in profiling food products and regularly participated in sensory analysis. Evaluation of samples was conducted under white fluorescent light and the booth area was maintained at 22±2°C temperature and 50±5% relative humidity. The *ragi mudde* samples were served in porcelain dishes coded with 3 digit code number. A glass of lukewarm water was also served to cleanse the palates. Panelists were asked to mark the perceived intensity of each attribute listed on the scorecard by drawing a vertical line on a scale of 0-15 cm. The scale was anchored at 1.25 cm on either end, representing 'Recognition threshold' and 'Saturation threshold'. The scores given by the panelists for all the attributes of each sample were tabulated and the mean values were calculated, representing the panelist's judgment about the sensory analysis of the product. The sensory scores were graphically represented as 'Sensory profile'.

Statistical analysis

The experiment was performed with 3 independent trials, and the data were presented as mean ± standard deviation (SD). Statistics were done by using Microsoft excel 2007 (Microsoft corp, Redmond, USA).

Results

The various flour fractions of ragi played an important role in the preparation of *ragi mudde* and influenced the overall cooking quality, color, texture, and consistency of *mudde*.

Proximate analysis of different flour fractions of ragi

The nutrient composition of the RF samples (S1-S5) from different flour fractions is summarized in Table 1. The moisture content of all the samples varied from 12.3 to 13.3%. The ash content was found less in fine fractions as compared to coarse fractions. Among the samples, the higher ash content of 2.11% and 2.28% was observed for coarse fractions S4 and S5 respectively. However, protein, fat and total dietary fibers showed a significant difference for S1-S5 from 3.57±0.09 to 8.12±0.09, 0.39±0.07 to 1.22±0.04 and 10.53±0.08 to 21.50±0.01, respectively and the results were comparable with the study conducted by Borreli and Ushakumari[24,25]. The coarse fracton of RF was rich in total dietary fiber (21.50%), of which insoluble and soluble dietary fiber was 19.27 and 2.23% respectively. The RF coarse fraction (600-750 µm) exhibited a stronger

Table 1 — Proximate analysis and physical parameters of different flour fractions of ragi

	Flour fractions				
Parameters#	S1 (150 µ)	S2 (300 µ)	S3 (450 µ)	S4 (600 µ)	S5 (750 µ)
Moisture (g %)	12.34±0.00	12.85±0.02	12.91±0.32	12.95±0.24	13.3±0.00
Protein (g %)	3.57±0.09	6.05±0.20	6.71±0.03	7.68±0.01	8.12±0.08
Fat (g %)	0.39±0.07	0.42±0.09	0.73±0.05	0.81±0.12	1.22±0.04
Carbohydrates (g %)	70.29±0.05	71.32±0.02	71.55±0.01	72.30±0.06	73.56±0.09
Insoluble	9.97±0.06	14.27±0.08	16.97±0.07	18.15±0.09	19.27±0.05
Soluble	0.56±0.08	0.65±0.01	0.95±0.02	1.55±0.06	2.23±0.05
Total dietary fiber (g %)	10.53±0.08	14.92±0.02	17.92±0.00	19.70±0.04	21.50±0.01
Ash (g %)	1.17±0.06	1.58±0.11	1.92±0.02	2.11±0.04	2.28±0.12
Bulk density (g/mL)	1.81±0.24	1.42±0.12	1.25±0.32	1.11±0.02	1.05±0.04
Water uptake ratio 100 g/mL	175±0.32	180±0.07	187±0.03	190±0.25	200±0.02

#Values are mean±standard deviation of three replicates (dry weight basis)

Table 2 — Color measurement and textural characteristics of ragi mudde prepared using different flour fractions of ragi

	Flour fractions				
Parameters#	S1 (150 µ)	S2 (300 µ)	S3 (450 µ)	S4 (600 µ)	S5 (750 µ)
		Color			
L*	44.83±0.03	34.94±0.07	32.05±0.20	31.17±0.04	30.29±0.04
a*	6.66±0.06	7.12±0.02	8.4±0.12	8.75±0.13	9.6±0.06
b*	17.81±0.08	13.11±0.00	8.88±0.07	9.68±0.07	7.45±0.17
De	58.35±0.06	66.69±0.08	68.6±0.08	69.13±0.09	70.52±0.01
		Texture			
Hardness(N)	24.66±0.32	23.75±0.51	26.17±0.12	18.000±0.27	18.36±0.48
Stiffness (kgf/mm)	0.56±0.02	0.55±0.06	0.53±00.02	0.40±0.06	0.42±0.04
Adhesiveness (kgf/mm)	0.91±0.36	0.45±0.17	0.22±0.22	0.19±0.17	0.17±0.15
Cohesiveness	0.47±0.00	0.31±0.03	0.31±0.2	0.31±0.05	0.29±0.01
Springiness	6.48±0.32	3.78±0.37	3.88±0.03	3.66±0.10	3.29±0.37
Stickiness	1.19±0.02	0.76±0.13	0.84±0.11	0.55±0.02	0.55±0.12

#Values are mean±standard deviation of three replicates

dough consistency as compared to the fine RF fractions which could be due to the presence of higher protein content in coarse RF fractions. Between the fine and coarse flour fractions, the fine RF was characterized by lower nutrient components which was due to the removal of outer coat bran while sieving[26]. Proximate analysis of the RF fractions confirmed that the nutrient compositions decreased with the reduction in particle size.

Bulk density

The relation between the mean particle size and bulk density of RF is shown in Fig. 1. A negative correlation was found between mean particle size and bulk density ($r = -0.901$, $p \leq 0.05$). The bulk density of RF decreased with an increase in particle size. This could be due to the presence of a higher seed coat in coarse fractions as shown by ash content.

Water uptake ratio

The water uptake ratio increased slightly towards the coarse fraction, whereas cooking time showed no difference among the four fractions (Table 1).

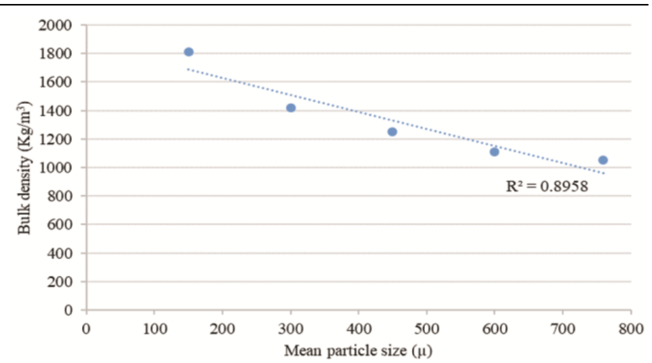

Fig. 1 — Relations between mean particle size and bulk density

Color measurements

The color measurements of *ragi mudde* substituted with different fractions of RF are depicted in (Table 2). The color of *ragi mudde* is generally light to dark brown. The positive a* values indicate the samples developed a uniform tinge of red color. A significant increase in redness values was observed with an increase in the particle size (coarse fraction). The redness value is the indication of the presence of seed coat in the RF. On the other hand, positive values of b* decreased with an increase in the particle size. The yellow color was more predominant in mudde with fine particles of RF as shown by a comparatively higher b* value. The L values represent the lightness was higher for the fine fraction and lower for coarse fractions as shown by the values. The L values decreased from 44.83 to 30.29 with an increase in the particle size. This could be due to the presence of a higher seed coat in coarse fractions. The ΔE values were lower for the fine fractions compared to the coarse fractions. The darker *mudde* showed ΔE values of more than 45. The results indicate that the seed coat which contains polyphenols present in ragi, gives dark color in higher coarse flour, and darkness gets slightly decreased in fine coarse flour. This may be due to the oxidation of the phenolics present in RF.

Textural characteristics

Textural attributes of five samples (S1-S5) of *ragi mudde* derived from TPA are presented in Fig. 2. The results showed significant differences in the textural attributes such as hardness, stickiness, stiffness, adhesiveness, cohesiveness, and springiness for the different fractions of *ragi mudde*. The hardness value of the *ragi mudde* for a fine fraction is 24.66 N, which reduces drastically to 18.36N for a coarse fraction (Table 2). The lower values of hardness and cohesiveness indicate that *mudde* cooks to a soft texture for the coarse fraction. More stickiness, springiness, hardness and adhesiveness were observed with fine fractions apart from formation of lumpish, stiffy and cohesive mudde when compared to coarser fractions. This may be due to increased starch damage in fine fractions of RF.

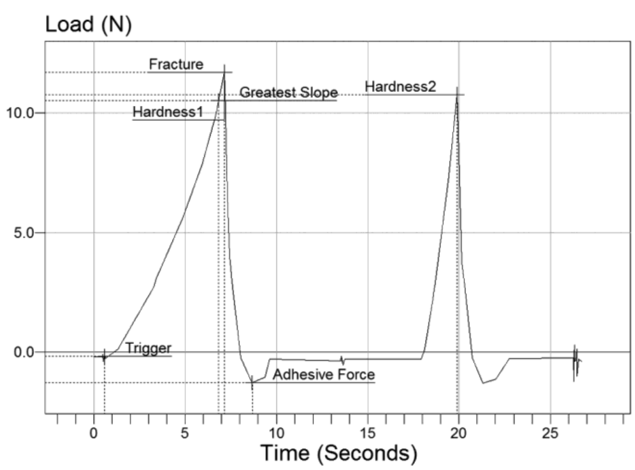

Fig. 2 — Force deformation curves of ragi mudde

Sensory analysis

Ranking test

The Friedman's test results showed that there was a noteworthy difference between the samples S1 (150 µm), S2 (300 µm), S3 (450 µm), S4 (600 µm) and S5 (750 µm) for the attributes color and texture. The samples were ranked in the increasing order of intensity of color with S1 (150 µm) as the least intense and S5 (750 µm) as the most intense. It was also observed that the sample S1 was comparatively softer and sticky in nature.

Statistical analysis of the preference ranking test (Fig. 3) revealed that sample S4 was the best and superior and sample S1 was inferior among the group. Data from preference ranking indicated that S4 was the most preferred sample followed by S5, S3, S2 and S1.

Quantitative descriptive analysis

The sensory profiles of *ragi mudde* samples are depicted in Fig. 4 and it was observed that the sensory

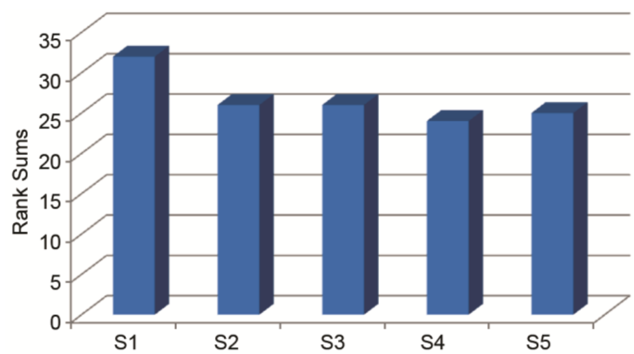

Fig. 3 — Rank sum scores for ragi mudde OQ* Lower rank sum scores indicate higher overall quality and higher rank sum scores indicate lower quality S1-150 µ, S2-300 µ, S3-450 µ, S4-600 µ and S5-750 µ fractions of RF

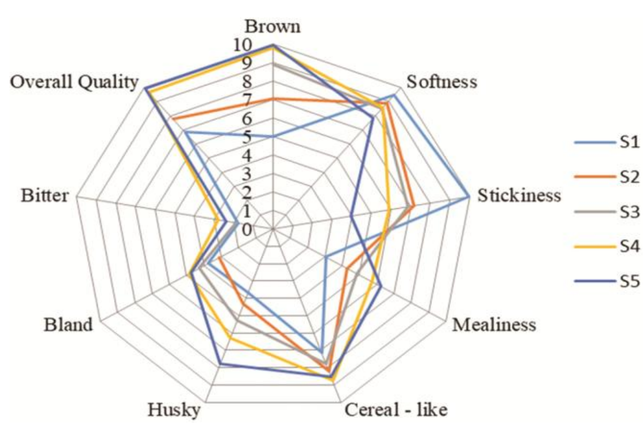

Fig. 4 — Sensory profile of ragi mudde S1-150 µ, S2-300 µ, S3-450 µ, S4-600 µ and S5-750 µ fractions of RF

scores of *ragi mudde* in terms of color, texture, appearance, taste and overall quality were comparable between the fractions of RF. The results showed that there was a significant difference in the color of *ragi mudde* which was ash in color for S1 (fine flour) and was a brown color with varying degrees of brightness for samples S2, S3, S4 and S5. Samples S1 and S2 were quite soft and sticky in nature and were lacking in most of the desirable sensory attributes. The sample S2 (near to fine) had the least score for brown color indicating that it was the lightest in color. Samples S4 & S5 (coarse fractions) had the highest score for brown color, which could be due to the presence of husk particles. It was also observed that samples S4 and S5 had perceived mealiness and husky aroma notes. All the *ragi mudde* samples had a bland taste. There was no noticeable off-odor or off-taste in all the samples. The overall quality score indicated the mudde prepared from coarse RF (600-750 µm) which had higher intensity of brown color, desirable softness, and less stickiness was highly acceptable.

Conclusion

The study revealed that the conventional method of cooking of *ragi mudde* could be a quick cooking process. The particle size of RF showed variation in fat, protein, ash and dietary fiber and had negative correlation with bulk density. The coarse fraction of ragi (RF 600-750 µm) showed stronger dough characteristics as compared to the fine fractions. Instrumental color and texture values of *ragi mudde* showed a significant difference between the fractions. The study indicates that the coarseness or fineness of RF has great influence on the physical and sensory qualities of *ragi mudde* & the RF particle size of 600-750 µm suits best and is ideal for the preparation of the best quality *ragi mudde*. From the present study, it can be concluded that the flour particle size has a significant role in the quality of *ragi mudde*. The different particle sizes of RF can be used in the production of specialty products. This study is useful in preserving the traditional cuisine of India.

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Conflict of Interest

Authors declare there are no conflicts of interest.

Authors' Contributions

The study design and concept by SCG and NVD; acquisition of research data by SCG, AS and NVD; analysis and interpretation of research data by SCG, AS, RG and NVD; manuscript drafting by SCG and AS; manuscript revising for critically intellectual content by SCG and AS; final approval of manuscript by SCG, AS, RG and NVD.

References

1 Prabhu K S, Das A B & Dikshit N, Assessment of genetic diversity in ragi [*Eleusine coracana* (L.) Gaertn] using morphological, RAPD and SSR markers, *Z Naturforsch C*, 73 (5-6), (2018) 165-176.

2 Ramashia S E, Gwata E T, Meddows-Taylor S, Anyasi T A & Jideani A I O, Some physical and functional properties of finger millet (*Eleusine coracana*) obtained in sub-Saharan Africa, *Int Food Res J*, 104 (2018) 110-118.

3 Mudau M, Ramashia S E, Mashau M E & Silungwe H, Physicochemical characteristics of bread partially substituted with finger millet (*Eleusine corocana*) flour, *Braz J Food Technol*, 24 (2021).

4 Chethan S & Malleshi N G, Finger millet polyphenols: Optimization of extraction and the effect of pH on their stability, *Food Chem*, 105 (2) (2007) 862-870.

5 Devi P B, Vijayabharathi R, Sathyabama S, Malleshi N G & Priyadarisini VB, Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: a review, *J Food Sci Technol*, 51 (6) (2014) 1021-1040.

6 Rai M, Productivity grain focus. Survey of Indian Agriculture, (The Hindu), 2000, p. 53-55.

7 BN S, Ramakrishna M G & Prakash J, Formulation of nutrient dense Chapatti premix suitable for diabetics, *Indian J Tradit Know*, 20 (3) (2021) 852-859.

8 Shobana S & Malleshi N G, Preparation and functional properties of decorticated finger millet (*Eleusine coracana*), *J Food Eng*, 79 (2) (2007) 529-538.

9 Viswanath V, Urooj A & Malleshi N G, Evaluation of antioxidant and antimicrobial properties of finger millet polyphenols (*Eleusine coracana*), *Food Chem*, 114 (1) (2009) 340-346.

10 Pradeep P M & Sreerama Y N, Impact of processing on the phenolic profiles of small millets: Evaluation of their antioxidant and enzyme inhibitory properties associated with hyperglycemia, *Food Chem*, 169 (2015) 455-463.

11 Malleshi N G & Hadimani N A, Nutritional and technological characteristics of small millets and preparation of value added products from them, Advances in small millet Proceeding of Second International Small Millet workshop, (Bulawayo, Zimbabwe), 1993, p. 271-288.

12 Gavurníková S, Havrlentová M, Mendel Ľ, Čičová I, Bieliková M, *et al*., Parameters of wheat flour, dough and bread fortified by buckwheat and millet flours, *Agriculture* (*Pol'nohospodárstvo*), 57 (4) (2011) 144-153.

13 Subba D & Katawal S B, Effect of particle size of rice flour on physical and sensory properties of seli-roti, *J Food Sci Technol*, 50 (1) (2013) 181-185.

14 Thakur S, Scanlon M G, Tyler R T, Milani A & Paliwal J, Pulse flour characteristics from a wheat flour miller's

perspective: A comprehensive review, *Compr Rev Food Sci Food Saf*, 18 (3) (2019) 775-797.

15 AACC (American Association of Cereal Chemists), Approved Methods of American Association of Cereal Chemists, 10th edn. St Paul, MN, USA, 2000.

16 Asp N G, Jonsson C G, Hollmer H, *et al*., Rapid enzimatic assay of insoluble and soluble dietary fiber, *J Agric Food Chem*, 31 (3) (1983) 476-482.

17 Jones D, Chinnaswamy R, Tan Y & Hanna M, Physiochemical properties of ready-to-eat breakfast cereals, *Cereal Foods World*, 45 (4) (2000) 164-168.

18 Kuehni R G, Color-tolerance data and the tentative CIE 1976 L* a* b* formula, *J Opt Soc Am*, 66 (5) (1976) 497-500.

19 Krishnamurthy S & Kantha H J, Applications of universal testing machine (UTM) for food texture analysis, *J Instr Soc*, 33 (1) (2003) 60-73.

20 Meilgard M, Civille G V & Carr B T, Sensory evaluation techniques, 3rd edn, (CRC, Boca Raton), 1999.

21 Friedman M, The use of ranks to avoid the assumption of normality implicit in the analysis of variance, *J Am Stat Assoc*, 32 (1937) 675.

22 Kramers A, Kahan G, Cooper D & Papavasilion A, A non-parametric ranking method for the statistic evaluation of sensory data, *Chem Sens Flav*, 1 (1974) 121-133.

23 Stone H, Sidel J, Oliver S, Woolsey A, *et al*., Sensory evaluation by quantitative descriptive analysis, Vol 28, (Descriptive Sensory Analysis in Practice), 2008, p. 23-34.

24 Borrelli G M, De Leonardis A M, Platani C, *et al*., Distribution along durum wheat kernel of the components involved in semolina colour, *J Cereal Sci*, 48 (2) (2008) 494-502.

25 Ushakumari S R, Latha S & Malleshi N G, The functional properties of popped, flaked, extruded and roller dried foxtail millet (*Setaria italica*), *Int J Food Sci Technol*, 39 (9) (2004) 907-15.

26 Dharmaraj U, Rao B S, Sakhare S D, *et al*., Preparation of semolina from foxtail millet (*Setaria italica*) and evaluation of its quality characteristics, *J Cereal Sci*, 68 (2016) 1-7.