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Formulation of nutrient dense Chapatti premix suitable for diabetics

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Wheat is one of the largest cereal grown around the world and is used as staple in many countries. Since processing or refining of wheat removes many essential nutrients, its nutritional quality is reduced. The aim of the present study was to develop a supplemental nutritious premix based on natural ingredients using dry greens, pulses and spices, and to evaluate their efficacy for value addition, which in turn can combat micronutrient deficiency and can be advised for diabetics. Premix was incorporated to chapatis at 12.5% and 25% levels and estimated for chemical composition and antioxidant activity. Results showed that premix was rich source of protein (12 to 14.78%), insoluble dietary fiber (16.9 to 18.6%), calcium (150 to 244 mg/100 g), total and β-carotene and bioactive components. Antioxidant activity indicated that premix incorporated samples had higher activity than control. Thus, it can be concluded that nutritional quality of chapattis can be enhanced by incorporating nutritious premix.

Keywords: Antioxidant components, Antioxidant activity, Bioaccessible minerals, Drumstick leaves, Dried onion powder, *Kilkeerai* greens, Sensory quality

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In developing countries multiple micronutrient deficiency is more prevalent than single micronutrient deficiency. Low dietary intake by populations and poor bioaccessibility of micronutrients are the causes for such high preponderance. Food-based approach though difficult and of long duration, its effect is predicted to be long lasting. Basically food-based interference focus on either in combination or all of natural, processed or fortified food as to prevent malnutrition and nutritional deficiencies thereby improving the quality of the diet[1].

Rapid urbanization and changes in occupation patterns, lifestyles and family structures have together influenced the eating pattern. A large shift from consumption of coarse grains to polished cereals has decreased the overall fiber and bioactive contents of the diet, which in turn is associated with non-communicable diseases such as obesity, diabetes etc[2]. This can be prevented by consumption of complex carbohydrates in the day to day diet.

Chapattis, a traditional staple in Indian households and eaten by people of all age groups, has been used as a medium to improve nutritional quality. As whole wheat flour chapatis contain good amount of dietary fiber, by adding nutritious premix to the wheat flour while kneading the dough could further improve the overall quality of the chapattis. Wheat flour which contains around 8-12% protein has limiting essential amino acid, so partial addition of premix containing defatted soy flour, legumes, greens, bran and spices in different proportions will help to improve the nutritional value of chapattis. Addition of premix can reduce the energy density, which would be helpful for diabetics and obese individuals. Hence, the present study focused to alter the traditional product by formulating nutritious premix utilizing natural ingredients and to incorporate them into a product, study its nutritional quality and sensory acceptability.

Materials & Methods

Study design and chemicals

The study design involved preparations of nutritious premixes utilizing nutrient-dense ingredients and addition of the premix to chapattis, a traditionally used staple of India. The products were analysed for nutritional composition, bioaccessibility of minerals, *in vitro* digestibility of starch and protein, antioxidant components, antioxidant activities and sensory quality. Analytical grade chemicals were used for the study. Reagents such as gallic acid, trolox,

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catechin and Folin-Ciocalteu were purchased from Sigma-Aldrich Co., (St. Louis, MO, USA). Entire chemical analysis was carried out using double distilled water. The food ingredients were sourced from local markets.

Preparation of premix and chapatis

The ingredients and proportions used for preparation of premix were as follows, 16 g each of horse gram (*Macrotyloma uniflorum*), cow pea (*Vigna unguiculata*), dried onions (*Allium cepa* L), wheat bran (*Triticum aestivum*) and defatted soy flour (*Glycine max*); 12 g each of dried drumstick leaves (*Moringa oleifera*) and *kilkeerai* leaves (*Amaranthus tricolor*); 4.0 g of cumin seeds (*Cuminum cyminum*) and 2.0 g of omum seeds (*Trachyspermum ammi*) making a total of 110 g. Greens were cleaned thoroughly and washed with tap water followed by distilled water. The leaves and peeled onions were dried in oven at 50±1°C. All ingredients were powdered using lab grinder and mixed thoroughly and stored in air tight containers.

Whole wheat flour (*Triticum aestivum*) was used for preparation of chapatis in traditional way by mixing with water and salt. Control products did not have any premix; for experimental products, premix replaced wheat flour at 12.5% and 25%.

Analysis of moisture, fat, protein, total ash, minerals and antinutrients

Prepared products were analyzed for analysis of nutritional composition. According to Association of Official Analytical Chemists[3] the analysis of moisture, fat, protein, total ash was estimated. Minerals were estimated from the ash solution by ICP-OES. Oxalates and phytic acid were determined by methods described by Baker[4] and Thompson[5].

Analysis of in vitro starch and protein digestibility, dietary fiber and bioaccessibility of minerals

The methods given by Kon[6], Holm[7] and Som[8] were modified to determine the *in vitro* starch digestibility. In addition, resistant starch was subjected to the Englyst assay method[9]. Enzymatic method[10] was used to estimate digestibility of proteins. Enzymatic gravimetric method[11] was used to determine dietary fiber which consists both soluble and insoluble. Using mineral dialysability[12] the *in vitro* bioaccessibility of minerals such as calcium, iron and zinc were determined. The dialysate was analyzed for the above minerals by ICP-OES method.

Preparation of sample extracts in solvents

Total phenols, flavonoids, tannins and for determination of antioxidant activity the powdered samples were extracted in methanol and aqueous media. Fresh extracts were used to carry out all the analysis.

Analysis of total phenols, flavonoids, tannins and carotenoids

Total phenols were estimated according to Folin-Ciocalteu method[13]. To an aliquot of extract, Folin-Ciocalteu reagent and saturated solution of Na_2Co_3 was added. The solution was made up to 10 ml with distilled water and kept aside for 30 mins and optical density was measured at 765 nm and the results were expressed as mg tannic acid equivalents (TAE)/100 g of sample. Total flavonoids were estimated according to the method given by Jia and Tang[14] and the results were expressed as mg catechin equivalents/100 g sample. Vanillin-HCl method[15] was used to determine condensed tannins and results were expressed as milligrams of (+)- catechin equivalents per gram. Total and β-carotene were estimated colorimetrically described by the method[16] using petroleum ether for baseline correction.

Antioxidant activities by different methods

DPPH (2,2´-diphenyl-1- picrylhydrazyl) radical is used to determine the free radical scavenging activity according to Brand-Williams[17] method. For Frap assay the modified method of Benzie and Strain[18] was used. The results were expressed as micromoles of ferrous equivalent per 100 g of sample (µmol Fe^{2+}/100 g). Ferrous ions chelating effect was carried out using the method[19]. Reducing power assay[20] was performed to estimate antioxidant activity in which the increased absorbance of their action mixture indicated increased reducing power.

Moisture sorption isotherm

The method used for determination of moisture sorption isotherm was based on Labuza[21]. Initially around 5.0 g of samples were weighed in petri dishes and dried in vacuum oven maintained at 70°C for 8 h. Different salts such as potassium acetate, magnesium chloride, potassium carbonate, magnesium nitrate, sodium nitrite and potassium chloride were used to determine moisture uptake by the premix.

Sensory analysis

Score card for sensory analysis of samples were coded and performed by a panel consisting of semi trained (n=30) members. Panelists were asked to mark for appearance, color, texture, taste, aroma

and overall quality. Free choice profiling[22] was used for descriptive test.

Statistical analysis

Results of three measurements were expressed as mean standard deviation (SD). Student's T test at $p<0.05$ was used to test the significant difference in the samples. MS Excel was used for the above analysis.

Results and Discussion

Chemical composition and available nutrients

The results are presented in Table 1 to 4 and Figure 1-3. The chemical composition of formulated chapatis with and without premix is tabulated in Table 1. The moisture content of chapattis was almost similar in control as well premix incorporated products (29.8 to 30.9%). Fat on the other hand was slightly higher in premix incorporated chapattis i.e., 1.33 and 1.44% compared to control (0.81%). However, differences were statistically insignificant. Protein content was significantly higher in chapattis incorporated with premix at 12.5% and 25% (12 and 14.78%) compared to control (11.06%). The addition of defatted soy protein could be the reason for higher protein content in premix compared to control samples as greens are generally low in protein. In a study by Oghbaei and Prakash[23], similar products which were fortified with minerals were analyzed for protein and the values were 11.97 to 12.54%, which were close to our results. Total ash content also was high in chapatis with premix addition and ranged from 2.13 to 2.76% showing that the experimental products were richer sources of minerals than control i.e., 1.44%. Accordingly, both calcium and iron were much higher in products with premix. Calcium content of control product was 34.9 mg/100 g and with 12.5% of premix, a fivefold increase was seen i.e., 150 mg and with 25% premix, it further increased to 244 mg/100 g indicating that addition of premix increased calcium content of chapati tremendously. In a similar way, phosphorus content was also high in premix added products (394 to 552 mg/100 g)

Table 1 — Chemical composition of chapatti (Per 100 g dry weight basis)

Parameters	Control	Premix (12.5%)	Premix (25%)
Moisture[#](g)	29.9±0.53	30.9±0.08	29.8±0.40
Fat (g)	0.81±0.08	1.33±0.25 ^{ns}	1.44±0.33 ^{ns}
Protein (g)	11.06±0.15	12.03±0.15*	14.78±0.00*
Ash (g)	1.44±0.03	2.13±0.04*	2.76 ±0.08*
Calcium (mg)	35.0±0.21	150±0.21***	244±0.70***
Iron (mg)	7.92±0.25	13.65±0.49**	19.05 ±0.07**
Zinc (mg)	2.09±0.07	3.28 ±0.26 ^{ns}	3.80±0.27*
Manganese (mg)	2.09±0.01	3.10±0.20*	3.55±0.07*
Magnesium (mg)	86.2±0.01	177±0.91**	229 ±0.14***
Potassium (mg)	244±1.76	477±1.06***	631 ±0.70***
Phosphorus (mg)	287±0.21	394±1.83**	551 ±1.13**
Copper (mg)	0.45±0.00	0.61±0.00**	0.65 ±0.00**
Sodium (mg)	12.1±0.35	26.1±0.14**	44.2 ±0.21**
Oxalate (mg)	0.09±0.02	0.17±0.03*	0.16 ±0.03*
Phytic acid (mg)	236±7.5	259±24.4 ^{ns}	260 ±23.9 ^{ns}

#: Fresh weight

Significant differences between samples on application of Students 'T' test: *p≤ 0.05; **p≤ 0.01; ***p≤ 0.001; ns: not significant.

Table 2 — Carbohydrate profile and *in vitro* digestible/available nutrients in chapati (Per 100 g dry weight basis)

Parameters	Control	Premix (12.5%)	Premix (25%)
Total starch (g)	67.3±0.7	63.5±1.3*	63.7±2.1**
Digestible starch (g)	58.6±1.4	57.5 ±0.7 ^{ns}	42.6±0.6**
Resistant starch (g)	2.7±0.1	4.1±0.1**	3.4±0.1**
Insoluble dietary fiber (g)	12.5±0.00	16.9±0.13*	18.6±0.54
Soluble dietary fiber (g)	1.25±0.07	1.25±0.07 ^{ns}	2.10±0.14***
Digestible protein (g)	9.7±0.3	8.4±0.2*	9.0±0.0*
Bioaccessible iron (mg)	0.338±0.00	0.435±0.02*	0.366±0.0*
Bioaccessible calcium (mg)	22.9±0.63	26.2±0.35*	34.0±0.35*
Bioaccessible zinc (mg)	0.53±0.00	0.55±0.00*	0.43±0.02*

Significant differences between samples on application of students 'T' test: *p≤ 0.05; **p≤ 0.01; ***p≤ 0.001; ns: not significant.

Table 3 — Antioxidant components and antioxidant activity of chapati (per 100 g)

Parameters	Extracts	Control	Premix (12.5%)	Premix (25%)
Antioxidant components				
Total phenols (mg)	Methanol	31.20±0.57	67.80±2.55***	128.40±1.83***
	Aqueous	34.95±0.92	143.80±2.55***	169.40±2.55***
Flavonoids (mg)	Methanol	11.20± 0.14	172.50±3.54***	199.10±2.26***
	Aqueous	162.75±3.61	131.60±5.52 ns	235.95±5.59***
Tannins (mg)	Methanol	2.35±0.21	6.27±0.33***	9.50±0.14***
	Aqueous	0.65±0.21	2.75±0.07***	2.25±0.49***
Total carotenoid (mg)		1.05±0.21	2.36±0.11 ns	4.10±0.10**
β-carotene (µg)		ND	99.0±4.24	201.0±77.78
Antioxidant activity				
DPPH (mg as Trolox)	Methanol	38.55±1.48	45.79±0.61 ns	39.14±0.37 ns
	Aqueous	6.30±0.28	11.13±0.18***	8.13±0.18 ns
FRAP (mg)	Methanol	8.50±0.42	48.70±4.13***	66.60±1.98***
	Aqueous	15.90±0.42	21.90±1.56 ns	35.00±1.41***
Metal chelating (mg as EDTA)	Methanol	9.55± 0.49	10.23±0.16 ns	5.60±0.14***
	Aqueous	6.65±0.07	16.62±0.17***	1.60±0.14***

Significant differences between samples on application of students 'T' test: *p≤ 0.05; **p≤ 0.01; ***p≤ 0.001; ns: not significant.

Table 4 — Sensory scores of chapatti

Treatments	Control	12.5%	25%
Appearance	8.35±0.84	7.21±1.47**	6.78±1.57**
Color	8.42±0.42	7.07±1.32***	6.71±1.81**
Texture	7.50±1.01	7.14 ±1.40*	7.28±1.58 ns
Taste	7.85±0.77	7.78 ±1.47 ns	7.35 ±2.09 ns
Aroma	7.50±0.75	7.42 ±1.01 ns	7.21±1.67 ns
Overall quality	7.95±0.75	7.76 ±1.02 ns	7.90±1.67 ns

Significant differences between samples on application of students 'T' test: *p≤ 0.05; **p≤ 0.01; ***p≤ 0.001; ns: not significant.

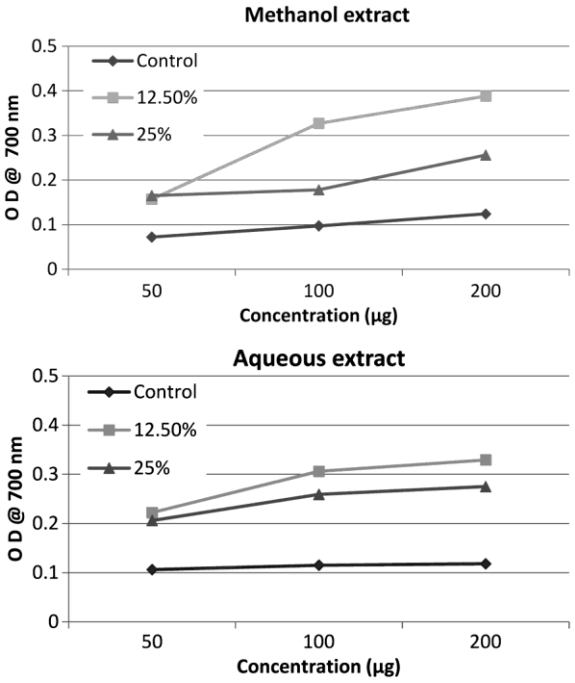

Fig. 1 — Reducing Power of chapati in methanol and aqueous extract

compared to control (287 mg/100 g). Both calcium and phosphorus are very important for formation of bone structure. The values for iron ranged from 13.65 to 19.05 mg/100 g in premix added products compared to control which had 7.92 mg/100 g. More than 50% of RDA for calcium, phosphorus and iron could be met by consuming 100 g of supplemented flour. Similarly, the other trace elements like copper, manganese and zinc ranged from 0.45 – 2.09 mg/100 g in control and in premix added products the values ranged from 0.61 – 3.80 mg/100 g. The other major elements like sodium, potassium and magnesium which are essential to maintain electrolyte balance were present in good amounts (Table 1). Thus, statistically extremely significant differences were seen between the premix added samples compared to control samples. At least a two-fold increase was noticed in most of the minerals analyzed. This is mainly due to addition of greens which are known to be rich sources of micronutrients such as minerals, vitamin A, iron, β-carotene, etc making the premix dense in nutrients and meeting the RDA's of the population. Anti-nutrients such as oxalates and phytates which are present in many foods especially greens bind the minerals. However, oxalate content was negligible in the products analyzed and ranged from 0.09-0.17 mg/100 g. Phytic acid on the other hand was high in premix added products (259-260 mg) compared to control products (235.7 mg/100 g), this increase could be because of soy flour as it is very rich in phytates, though increase was statistically insignificant.

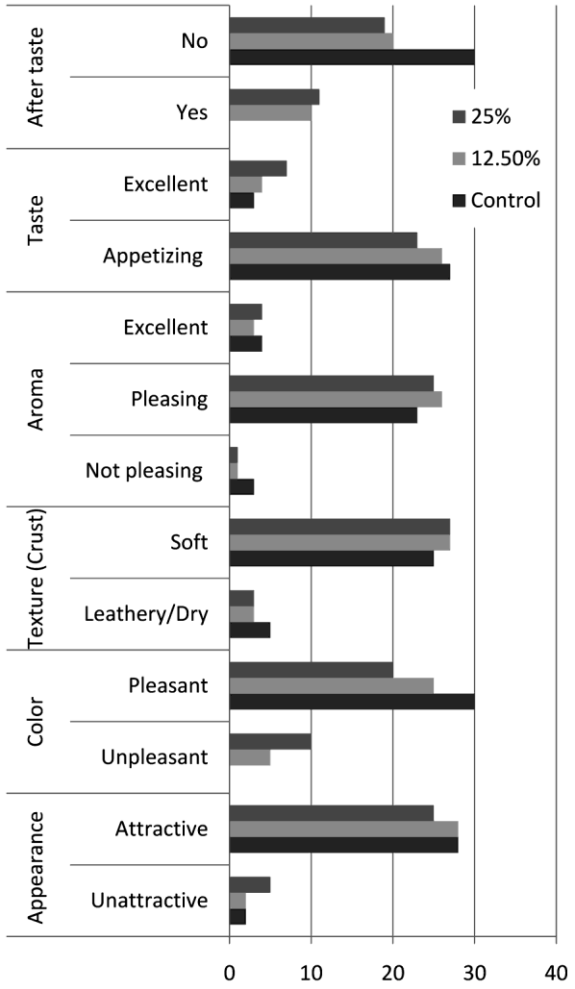

Fig. 2 — Free choice profile of chapatti

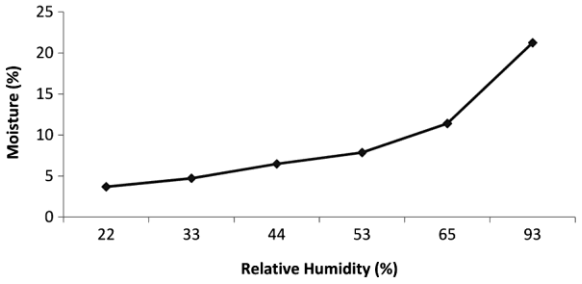

Fig. 3 — Moisture sorption isotherm of premix

The total starch content for control sample was 67.3%. Premix addition lowered starch content and the values ranged from 63.5 and 63.7% for 12.5% and 25% premix incorporated products respectively (Table 2). The differences were significant when compared to control. The digestible starch was higher in control sample (58.6%), and decreased to 57.5 and 42.6% in experimental products. Resistant starch is defined as "the sum of starch and products of starch degradation not absorbed in the small intestine of healthy individuals"[24]. Resistant starch was high in premix added products compared to control thus indicating that addition of premix would in turn reduce the glycemic index of chapati and could be used for diabetics. Statistically highly significant differences were noted between premix incorporated and control samples. Generally resistant starches which are manufactured commercially are generally used to increase the total dietary fiber content of food[25]. Beneficial effects of dietary fiber in the management of diabetics have been well recognized. The insoluble dietary fiber was high in premix added products (16.9% to 18.6%) compared to control (12.5%). Study by Faiza[26] reported a higher insoluble fiber content of 25% in formulated premixes. Hence, dietary fiber becomes an essential non-nutrient, the importance of which is well documented. Digestible protein was almost similar in control (9.7 g/100 g) and premix added products (8.4 and 9.0 g/100 g) showing that protein is equally available in both control and premix added products. Bioaccessibility of minerals is impacted by the presence of anti-nutrients which possibly interfere with mineral absorption. Multivalent metal ions such as zinc, calcium and iron get bound to antinutrients such as oxalic acid and phytates. Hence, bioaccessibility of these ions becomes poor, resulting in insoluble complexes. Thus, the dietary components such as oxalic acid, tannins, dietary fiber and phytic acid present in food[27] influences the bioaccessibility of minerals. Bioaccessibility of iron and zinc were more in 12.5% and lesser in 25% premix added products respectively and this could be because of presence of soy phytates. However, in case of calcium bioaccessibility the increase was not influenced by phytic acid and the substantial increase in content was because of greens, hence was not affected. Thus, the above results show that premix incorporation supported mineral bioaccessbility (Table 2).

Antioxidant components and antioxidant activities

To assess the antioxidant capacity and as a preliminary screen for any product that is intended to be used as a natural source of antioxidants in functional foods, phenolic content can be used as an important indicator and potentially these phenolics compounds are health promoting[28,29]. Analysis for total phenols was carried out in both aqueous and methanolic extracts of the products. Higher values were found in premix added samples compared to

control. The values for control samples were 31.20 and 34.95 mg TAE/100 g in methanol and aqueous extracts respectively (Table 3). In methanol extracts, premix incorporated samples had values ranging from 67.80 to 128.40 mg TAE/100 g and the values ranged from 143.80 to 169.40 mg TAE/100 g in case of aqueous extracts. In comparison to control samples, the differences were extremely significant. Increase in phenolics in chapatis was observed on addition of premix, as these were rich sources of total phenols. The flavonoid content of control sample was 131.60 mg CE/100 g in methanol extracts and 11.70 mg CE/100 g in aqueous extracts. In the premix incorporated samples the values ranged from 172.25 to 235.92 mg CE/100 g in methanol and 172.50 to 199.10 mg CE/100 g in aqueous extracts, which were higher than the control samples. Compared to aqueous extracts, tannin values were higher in methanol extracts and the values were higher in premix incorporated chapattis (6.27 to 9.50 mg/100 g) compared to control (2.35 mg/100 g). Similarly, the values were higher in premix added samples (2.25 to 2.75 mg/100 g) compared to control (0.65 mg/100 g) in aqueous extracts. For both flavonoids and tannins, the differences were extremely significant compared to control samples. It is to be noted that a small amount of greens is sufficient to provide recommended dietary allowances (RDA) of vitamin A as they are rich sources of carotenoids. The total and β-carotene content were increased by the addition of premix (Table 3). Compared to control (1.05 mg/ 100 g), the total carotenoid content almost doubled in premix added samples (2.36 to 4.1 mg /100 g). β-carotene content was not detected in control samples, however in premix treated samples it ranged from 99 to 201 mg/100 g. Thus, for carotenoids, highly significant difference was recorded. Accordingly, carotenoids are also known for their antioxidant function and green leafy vegetables which are added to the premix contain an immense variety of bioactives, non-nutritive health enhancing factors such as antioxidants, phytochemicals and dietary fibres etc. Hence all these together contribute to the general health.

In order to test the antioxidant activity of the products, four different methods were used. The compound that has been widely used to measure radical scavenging activity of different bioactives is 2, 2-diphenly-1-picrylhydrazl (DPPH). The results DPPH radical scavenging activities of chapattis were compiled in Table 3. The samples had high activity compared to control at 12.5% premix addition. However, the activity decreased at 25% premix addition. This could be due to pro-oxidant activity of a high amount of premix addition. When compared to control samples, highly significant differences were noted for free radical scavenging activity in aqueous extract. In comparison to the control samples, the ability of premix incorporated chapattis to reduce ferric ions was five times higher in methanol extract. At 25% addition, the values were almost twice when compared to control samples in case of aqueous extract. Statistically significant differences were recorded compared to control samples (Table 3). To assess the chelation capacity metal chelating activity was carried out (Table 3). Chelation power of the chapattis extracts illustrated that both methanol and aqueous extract at 12.5% addition possessed higher chelation power when compared to control and 25% premix added samples. Thus, methanol extract had 10.23 mg/100 g and aqueous extract had 16.62 mg/100 g capacity to chelate ions, at 12.5% premix addition, in comparison to control and 25% premix added samples. For both the extracts, significant differences were recorded. To a general view of reductones present in the sample, concentration dependency of antioxidant activity was investigated as a function of reducing power (Fig. 1). It was observed that methanol and aqueous extracts of premix incorporated chapattis were in similar range and had higher reducing power than control sample at all concentrations between 50-200 μL. Accordingly, antioxidant effect exponentially increases as a function of the development of the reducing power. This indicates that the antioxidant properties are concomitant with the development of reducing power. Thus, the redox properties which allow them to act as singlet oxygen quenchers, reducing agents, and heavy metal chelators are the key reasons behind the antioxidant activity of phenolic compounds. Thus multiple methods were used for determining the antioxidant activity. Lower activity was recorded in one method while it was recorded higher in other three methods. Efforts are always been made to minimize oxidation and improve oxidative stability of products as lipid oxidation has detrimental effects on both food quality and human health. So, in reducing the oxidative stability of the products, antioxidant activity becomes very important. This in turn helps in numerous oxidative stress-mediated diseases.

Sensory analysis

The sensory acceptability is extremely important as taste is a predominant determinant of food selection. The products prepared were imperiled to sensory analysis using two different sets of evaluation responses comprising a grading scale wherein products were scored by a set of 30 semi-trained panellists for different attributes, and a free choice profiling where the respondents specifically marked their responses in terms of descriptive quality. The results are summarized in Fig. 2 and Table 4.

The results of sensory analysis using a score card for grading of products showed that for the quality of appearance and colour, the control product was given a high scoring of 8.35 indicating excellent on the scale (Table 4). However, the scores came down on addition of premix for appearance and colour of the product. Highly significant differences were recorded when compared to control products. However, for the quality of texture, the control and experimental products scored almost similar scores ranging from 7.14 to 7.50. For taste, aroma and overall quality, a similar trend was noticed. Statistically there were no differences in all the above parameters i.e., taste, texture, aroma and overall quality. To summarize, incorporation of premix affected the appearance and colour of the product adversely, however, taste, texture, aroma and overall quality of the products were not affected.

Choice profiling for descriptive quality of chapattis is presented in Fig. 2. The choice profiling of chapattis with premix indicated that many panellists found the appearance and colour of experimental product to be equal to control product. This was unlike grading scale results wherein appearance was given low scores. They found it to be ‘attractive’ and ‘pleasant’. The textural quality of all the products was termed as soft, and their aroma was described as ‘pleasant’. The taste quality was also liked by many panellists, and they graded the products as ‘appetizing’. It can be said that the experimental products made with premix were similar to control in appearance, colour, texture, aroma and taste.

Moisture sorption of premix

To determine the storage stability, the formulated premix was subjected to moisture sorption studies. The premix was stored at different relative humidity (RH) and moisture uptake was monitored every 24 h by gravimetric technique, till it attained maximum moisture level. The data of moisture uptake was used for drawing moisture sorption curve; the results of which are presented in Fig. 3. The moisture uptake of the sample was low at RH of 22% reaching up to 3.69% indicating that at low RH, the samples were quite stable. The moisture uptake was slightly higher than the previous value at RH of 33% and it was 4.73% at the end of storage period. Again, a consistent but small increase was seen on increasing the RH at 44% which totaled up to 6.48%. The trend continued with a small increase in moisture uptake and it was 7.86% at RH of 53%. However, the moisture uptake was considerably high in the next level of RH, i.e., 65%, at 11.4% for premix. At RH of 93%, it was 21.2% and very high moisture absorption was seen. Using the moisture uptake value, sorption isotherm curve of premix was drawn and the result is presented in Fig. 3. As can be seen from the curve, the moisture uptake by sample was considerably low up to RH of 53%. However, the samples absorbed 11.4-21.2% moisture at higher RH of 65 and 93%, which was extremely high, indicating that the premix requires a proper packaging material to inhibit water ingress for longer shelf stability.

Conclusion

It can be concluded from the above study that the levels of premix added to the chapattis influenced the nutritional and sensory quality of the products. Outcome of the nutrient profiling of the premix showed that it is rich in a wide array of nutrients such as iron, calcium, protein and non-nutrients such as bioactive components. The ingredients used provide a basis for dietary management of people to reduce over dependence on drugs. Therefore, adoption, utilization and consumption of premix incorporated chapattis will be a step forward towards combating the micronutrient deficiencies as well to combat chronic degenerative disease such as diabetes as it is increasing at a rapid rate with changing dietary patterns associated with sedentary and stressful life styles. Therefore, the findings of the present study can be a valuable basis for preparation of home made products to improve the daily nutrition through dietary fiber, phenolic acids and protein.

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Conflict of interest

Authors report no conflict of interest with regard to the present research work.

Authors' contribution

SBN carried out bench work, study design, writing original draft; MGR assisted in laboratory analysis; and JP mentored the project, and helped in conceptualization, project administration, supervision, writing-original draft.

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