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Sensory and nutritional quality of *Moringa oleifera* leaf powder incorporated multi-millet ready to eat (RTE) snack

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The present study aimed at developing value-added multi-millet ready to eat (RTE) snack by incorporating *Moringa oleifera* (Drumstick) leaf powder (MOLP) at different concentrations viz., 0%, 5%, 10% 15% and evaluation of corresponding sensory and nutritional properties. The sensory evaluation revealed that newly formulated 5% MOLP snacks had higher overall sensory acceptability after control snacks. Besides, nutritional values also demonstrated that MOLP (15%) incorporated multi millet snacks contained abundant minerals including iron 99.09±0.6 mg/kg, zinc 20.27±0.3 mg/kg and calcium 4374±22.7 mg/kg. The protein (9.681±0.01 g/100 g) and antioxidants (230.6±0.46 µg/100 g) contents were also ($p<0.05$) higher, compared to control. The results suggested that incorporation of *Moringa* powder in RTE snacks production could be used to develop functional food with enhanced minerals, protein and antioxidants.

Keywords: Calcium, Drumstick, Iron, Millet, *Moringa* leaf powder, Sensory characteristics, Zinc

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Small portions eaten between meals are termed as snacks. Snacks are considered as fourth meal accounting to 25 percent of complete day's meals and include consumption of products viz., RTE foods chips, namkeen, bakery products and other processed foods[1]. Convenience foods such as RTE foods are consumed on a large scale as snacks, as these are easy to consume. Various studies document increased consumption of highly processed and convenience foods due to the factors including urbanization, changing lifestyles, changed food preferences, food habits and availability of foods in the market. Consumption trend of RTE products is growing rapidly and the Indian snacks market is currently worth 1530 crore. Potato chips alone in the snack's category lead in production with 85% of market share[2]. Increased consumption of empty calorie food along with a decline in coarse cereals consumption and whole grains is associated with increased incidences of various health ailments such as obesity, diabetes mellitus, metabolic syndrome, cardiovascular diseases, cerebrovascular diseases and cancer[3].

Millets are nutrient-dense grains and possess the potential to prevent various diseases and promote health. They are rich sources of minerals like calcium, iron, potassium, and zinc, vitamins like B complex, especially B6 and folacin, dietary fiber, polyphenol, protein, photochemical and micronutrients[4-7]. Calcium content of finger millet was 30 times higher than rice, while other millets have at least double the amount of calcium present in cereals.

Finger millet has 30 times more calcium than rice while every other millet has at least twice the amount of calcium compared to cereals. Pearl millet, foxtail millet, and sorghum have more minerals content like iron, zinc compared to rice and wheat flour[8].

Leaves of *Moringa oleifera* are good source of fiber, protein, vitamins and minerals like calcium, potassium, magnesium, iron and copper. The protein content as been determined twice and calcium as four times the amounts found in milk[9,10]. *Moringa* leaves are also rich in vitamins especially B-complex vitamins such as folic acid, pyridoxine and nicotinic acid, vitamin C, β-carotene and vitamin K[11,12]. A 6 spoonful of *M. oleifera* leaf powder consumed daily can meet pregnant women's requirement of iron and calcium. *Moringa* leaves are also rich in several antioxidant plant compounds[13,7] and phytosterols like sitosterol, stigmasterol and campesterol, that are important for the functioning of certain hormones in

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human nutrition[14]. Considering all these nutritional benefits, the leaves, seeds and bark are used in various preparations like salads, juices, soups, and medicine[15].

With recent food consumption patterns, it is evident that junk food and empty calorie foods are consumed as snacks leading to various health risks, such as obesity, metabolic syndrome, etc. Thus, it is necessary to formulate healthy and nutritious snacks as a substitute for these empty calorie foods. Hence, the present investigation was conducted to develop and standardize new innovative RTE snacks using dried MOLP along with millets (finger millet, pearl millet, finger millet and sorghum) for promotion of functional snack.

Materials and Methods

Raw materials procurement

Millets, black gram dhal, refined wheat flour, flaxseed, salt and chilli powder were procured from the local market.

Production of Moringa oleifera leaf powder (MOLP)

Moringa leaves were collected from Horticulture farm at Professor Jayashankar Telangana State Agricultural University campus and sorted for infected and damaged leaves. The leaves were washed three times with tap water and drip dried, followed by drying in tray dryer at 55°C for 6 h, after which the sample was ground using a food mixer grinder (Philips, HL1632). 100 g fresh leaves gave 20 g dried powder. The *MOLP* was packed in polythene (PE) bags, sealed and stored at 30°C for further studies.

Preparation of millet flours

Millets and other grains were cleaned and foreign materials were removed using sieves manually. The grains such as sorghum, pearl millet and foxtail millet were dehulled in an abrasive dehuller (Gurunanak Engineering Co, Hyderabad) to achieve 17% removal of bran, where as whole finger millet was used. The dehulled grains were then milled into flour in a mixer and sieved to get uniform particle size using mesh 0.1 mm sieve in the Millet Processing Incubation Centre and millet flours were packed and stored at 30°C in polyethylene (PE) bags for further studies. Preparation of multi-millet RTE snacks was done at Millet Processing Incubation Centre, Rajendranagar, Hyderabad.

Preparation of multi millet Ready to Eat (RTE) snack with an incorporation of Moringa oleifera leaf powder

Multi-millet snacks were developed using selected millets and other ingredients viz., black gram dal, wheat flour, flaxseed powder, chilli powder and salt with the incorporation of MOLP in different ratios. Three different variations were made, along with a control product with 0% MOLP (Table 1). Initially, the selected dry ingredients were weighed and mixed thoroughly and were converted to the dough using 70-75 mL of water, small balls were made from dough, which was rolled into thin layers (sheet 2 m) and cut into uniform shape with a knife. Snacks were deep-fried at 170°C for 10 min till it turned golden brown in colour. The chips were sprinkled with chat masala cooled at room temperature, packaged, and stored in sealed polythene bags till further use.

Sensory evaluation

The sensory assessments were conducted in a sensory evaluation laboratory. Semi trained panel members (21) from the Foods and Nutrition Department at Post Graduate and Research Centre, PJTSAU, Rajendranagar, Hyderabad, were selected as panellists for the study. They were given written instructions and asked to evaluate the products for acceptability in terms of appearance, color, texture, taste, flavour, crispness and overall acceptability using a nine-point hedonic scale, where 1= dislike extremely, 2 = dislike very much; 3 = dislike moderately; 4 = dislike slightly; 5 = neither like, nor dislike; 6 = like slightly; 7 = like moderately and 8 = like very much 9= Like extremely[16].

Nutritional properties of developed multi-millet RTE snacks

Evaluation of nutritional properties was done by following the methods[17]. Minerals were estimated by Inductively coupled plasma optical emission spectrometry (ICP-OES). Total protein content was estimated by the combustion method[18]. Antioxidant activity was estimated by using the method developed by Nikos[19].

Statistical analysis

All experiments were performed three times. All data were presented as means±standard deviation of the

Table 1 — Different compositions of multi millet RTE snacks

Ingredients	V1 (%)	V 2 (%)	V3 (%)	Control
Millets	59	54	49	64
MOLP	5	10	15	-
Refined flour	20	20	20	20
Black gram flour	10	10	10	10
Flaxseed powder	3	3	3	3
Salt	1	1	1	1
Chilli powder	2	2	2	2

Note: V1= 5%MOLP, V2= 5%MOLP and V3= 15%MOLP

mean. Multiple group comparisons and the significance and the significance of the differences among the treatment groups and their respective control groups were assessed by One-way analysis of variance (ANOVA) using Window stat 9.1 software. For statistical significance, differences between means were considered statistically significant at 5% level if $p<0.05$.

Results and Discussion

The control and MOLP incorporated snacks were tested for sensory and nutritional quality.

Sensory quality

The results for sensory analysis of multi-millet ready to eat snacks (Table 2, Fig. 1) showed that a significant difference was observed for sensory attributes of MOLP incorporated snack ($p<0.05$). 15% MOLP incorporated snacks had the lowest score in all attributes. Control had the highest score with more acceptability in all sensory attributes viz., colour, appearance, taste, texture, crispness and overall acceptability. Significant ($p<0.05$) decrease in overall acceptability was noticed in all MOLP incorporated snacks. However, the overall acceptability of 5% MOLP did not significantly differ from control. The addition of MOLP led to the dark green colour of snacks, and previous studies have suggested the colour as main attribute to like or dislike any product. Products developed using 10% and 15% level MOLP were disliked, which might be due to the dark green color. Among the tested formulations, only 5% MOLP product was acceptable. The decrease in likeness for the flavor of snacks might be due to the unique flavor of the leaf powder. Similar observations were reported by[20], where a significant difference was observed between control and treatments, indicating that the addition of different proportions of fresh *Moringa* leaves mixture affected the overall acceptability of the prepared pasta. Results suggested that incorporating MOLP as wheat flour replacers up to a level of 5%, could be well accepted and might vary based on the products and treatments used. To improve sensory acceptability, additives could be used to mask bitterness and improve appearance.

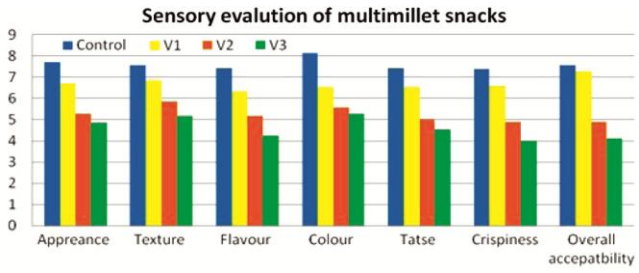

Fig. 1 — Mean sensory scores of multi-millet MOLP incorporated RTE snack

Effect of MOLP fortification on minerals, protein and antioxidant content of multi millet RTE snacks:

Iron

The results shown in Table 3 demonstrated a significant difference in iron content among 5%, 10%, 15% MOLP incorporated snacks and control variations ($p<0.05$). 15% MOLP product (99.09

Table 2 — Mean sensory scores of different variations of *Moringa oleifera* leaves incorporated RTE snacks

Sample	Appearance	Colour	Flavour	Texture	Taste	Crispiness	Overall acceptability
Control	7.714	8.143	7.429	7.571	7.429	7.381	7.571
V1	6.714	6.524	6.333	6.857	6.524	6.619	7.286
V2	5.286	5.571	5.190	5.857	5.000	4.905	4.905
V3	4.857	5.286	4.238	5.190	4.524	4.000	4.095

Note: V1= 5%MOLP, V2= 5%MOLP and V3= 15%MOLP

Table 3 — Mineral content of multi millet snacks (Value with the same superscript for the same nutrient are statistically similar ($p>0.05$) and those with different superscripts for the same nutrient are significant difference at 5% level).

Formulations	Minerals		
	Iron (mg/kg)	Zinc (mg/kg)	Calcium (mg/kg)
Control	90.85 ± 0.6^{c}	20.27 ± 0.3^{b}	1047 ± 1.1^{a}
V1	96.84 ± 0.7^{b}	21.05 ± 0.4^{b}	2432 ± 35.1^{b}
V2	96.17 ± 0.6^{b}	21.19 ± 0.08^{b}	3896 ± 13.2^{c}
V3	99.09 ± 0.6^{a}	23.02 ± 0.2^{a}	4374 ± 22.7^{d}
CD value	1.11819	0.52663	41.35580

Note: *V1= 5% MOLP, V2= 5% MOLP and V3= 15% MOLP*

Value with the same superscript for the same nutrient are statistically similar ($p>0.05$) and those with different superscripts for the same nutrient are significant difference at 5% level.

mg/kg) had the highest iron when compared to the other two variations and control products. All MOLP incorporated snacks had more iron compared to the control snacks (90.85 mg/kg). Iron content increased with increasing MOLP incorporation. It plays an important role in several metabolic processes such as transportation of oxygen and electrons, synthesis of deoxyribonucleic acid (DNA). Iron deficiency anaemia affects about a third of the world's population[21]. *Moringa* leaves have 25 times more iron than spinach[10]**.** Consumption of *Moringa* would help in the prevention of iron deficiency in vulnerable groups due to richness in iron (28 mg) which is more than that of beef and spinach[22].

Calcium

There was a significant increase in calcium content ($p<0.05$) from 1047 mg in control product to 4374 mg/kg in 15% MOLP product (Table 3). Iron and calcium content increased in the *Moringa* leaf powder incorporated bread[23], calcium increased significantly in the 12% MOLP incorporated muffin as the levels of supplementation increased[24]. The iron and calcium increased with increasing *Moringa* leaf powder in *uttapam*, idly and infant complementary foods[25,26]. Incorporation of MOLP enhanced the iron 8.30 and copper (3.10), magnesium (244.00) and calcium (442.20) mg/100 g contents in wheat bread respectively[27].

Calcium is considered as one of the important minerals for human growth and development. *Moringa* has three times more calcium compared to fruits and vegetables and fruits like oranges, banana and 17 times of calcium compared to milk[9]. Pregnant women can meet the daily requirement of calcium from six spoons of *Moringa* leaf powder[14]. The presence of minerals and vitamins help in boosting the immune system and cure a myriad of diseases. *Moringa* is easily cultivable and makes it a sustainable remedy for malnutrition. Calcium is one of the important minerals for human growth. Compared to 300–400 mg calcium content in eight ounces of milk, *Moringa* leaves contains 100 mg and 4000 mg in leaves and powder respectively[10]

The diets of the rural population can be fortified with *Moringa* leaves at a lower price and can serve as a low cost means of enhancing nutritional status as they can be easily dried using solar dryers and stored at domestic level. Formulations that can easily incorporate *Moringa* leaves in the traditional recipes will have the opportunity to serve as a less expensive β-carotene and mineral source in the countries where the *Moringa* can grow and adapt. Thus, it can help the children with low vitamin A status[2,28].

Zinc

Significant ($p<0.05$) difference was observed among the zinc content of control and MOLP added snacks. The15% MOLP variation had the highest zinc (23.02 mg/Kg), which was followed by 10% MOLP (21.05 mg/g). Higher the MOLP, higher the zinc content indicating beneficial effects of MOLP on the snacks. The ash content of *Moringa* muffin showed a significant increase in minerals, which was attributed to addition of dried MOLP and suggested similar applications can apply to snacks[24]. Zinc is also critical in neurologic function and plays a vital role in the immune system[29]. Consumption of dark green vegetable regularly in sufficient quantities can provide β-carotene and minerals and can contribute to the prevention of minerals deficiency in both children and adults.

Effect of MOLP on protein and antioxidant activity of Multi millet snacks

Protein

Protein content increased significantly ($p>0.05$) from 8.190 g (control) to 9.681 g (15% MOLP), which can also be attributed to dried *MOLP*, which is a rich source of protein. Similar results were reported[25-24], wherein protein content was observed lower (9.22 g) in a control sample of *idli* whereas higher value (11.46 g) was recorded in MOLP incorporated idly, control muffin (6.98 g) and 12% MOLP muffin (7.5 g). The increase in protein content could be attributed to the addition of MOLP and millets. Significant ($p< 0.05$) increase in protein content with the increasing level of supplementation from 9.07% in wheat flour (100%) to 13.79% in (95:5) wheat flour and *Moringa* leaf powder blend[23,30]. Aderinlola *et al.*, (2018) also reported a similar increase in total crude protein content of the smoothies by 157, 217 and 254% when MOLP was supplemented at 1.5, 3.0 and 4.5 levels, respectively[31]. *Moringa* had 2 times more protein compared to yogurt[9].

Antioxidant activity

The highest antioxidant content was observed in 15% MOLP (230.63 µg/100 g) multi millet RTE snacks, lowest in control product (122.3 µg/100 g) (Table 4). Antioxidant content increased with increasing incorporation of MOLP, similar results in the gluten-free bread[32].

Table 4 — Protein and antioxidant activity in multi millet snacks (Value with the same superscript (a-a) for the same nutrient are statistically similar (p>0.05) and those with different superscripts (a-b) for the same nutrient are significantly different at 5%).

Formulations	Nutrients	
	Protein (g/100 g)	Antioxidant activity (µg/100 g)
CONTROL	8.190±0.01^{d}	122.3±0.10^{d}
V1	8.850±0.01^{c}	139.6±0.16^{c}
V2	9.353±0.01 b	157.1± 0.10^{b}
V3	9.681±0.01a	230.6±0.46^{a}
CD value	0.01725	0.48294

Note: *V1= 5% MOLP, V2= 5% MOLP and V3= 15% MOLP*
Value with the same superscript (a-a) for the same nutrient are statistically similar (p>0.05) and those with different superscripts (a-b) for the same nutrient are Significant difference at 5%.

The addition of 2.5% MLP resulted in a large increase in the TPC content from 0.88 to 2.12 GAE/g in gluten-free bread. Similarly, addition of MLP 7.5% and 10% resulted in high activity for DPPH scavenging in gluten-free bread. Many authors also reported that the leaves of *Moringa oleifera* leaf, fresh or dried, as excellent sources of antioxidants, which have significantly higher antioxidant content compared to fruits such as strawberries, known for high antioxidant contents[11,14,33,34]. *Moringa* also has therapeutic benefits along with nutritional benefits; about 500 mg of *Moringa* seed powder/kg body weight in rats increased the antioxidant enzymes in the serum[35]. The antioxidants present in *Moringa* could bring down the ROS (Reactive Oxygen Species) caused in the Beta-cells due to the streptozotocin induction. *Moringa* is used as an anti-atherosclerotic agent[36], the anti-atherogenic nature can be accounted for by the antioxidant properties of *Moringa*. However, *Moringa* leaf extracts can act as antioxidants and anticancer agents and compounds of the leaves that are responsible for these actions are glucosinolates, niazimicin, and benzyl isothiocyanate[37].

Conclusion

Sorghum, finger millet flour, pearl millet, foxtail millet, black gram, flaxseed and *Moringa* leaves were found as good sources of calcium, iron, protein, and antioxidant activity content. The developed products using these grains could be one of the novel snacks with nutrient density and provide variety in daily diets. It can be concluded that this product promoted as a functional snack has the potential to prevent certain diseases associated with hidden hunger and oxidative stress.

Conflicts of Interest

Authors declare that there are no conflicts of interest

Author Contributions

M M conducted the experiment, developed the products, did statistical analysis and wrote the first draft of manuscript. H TV guided throughout the study, helped in designing the work, proof reading and critical correction of manuscript. M D B assisted in analysis, writing drafts and final corrections of manuscript.

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