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Development and Quality Evaluation of *Masala Khakhra* Fortified with Moringa Leaves Powder

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ABSTRACT

In the present study, *masala khakhra* was prepared by incorporating moringa leaves powder (MLP) at 2.5, 5, 7.5 and 10% levels. Results of organoleptic evaluation indicated that moringa leaves powder supplemented with 5% level was found best. Supplementation of MLP significantly (P≤0.05) increased the protein, fat, fiber, ash and phytochemical content of *masala khakhra*. Among the proximate composition, protein content ranged from 9.08-10.33%, fat content 9.37-10.44%, ash content 3.53-4.42% and crude fibre 1.62-2.30% with incorporation of MLP from 2.5-10%. The total phenolic content, total flavonoid content and antioxidant activity of *masala khakhras* increased significantly (P≤0.05) and ranged from 3.38-4.49 mg/g, 5.56-6.33 mg/g and 5.34-7.34%, respectively. Supplementation of MLP significantly (P≤0.05) affected the colour properties and hardness of *masala khakhra*. Textural analysis of *khakhras* showed an increase in the hardness (16.92-22.13N) with increasing levels of MLP from 2.5-10%. Colour values L* (50.81-39.09), a* (13.72-7.39) and b* (32.37-22.44) significantly (P≤0.05) decreased with incorporation of MLP from 2.5-10%.

Key words : Moringa, *khakhra*, sensory, nutritional, flavanoids

INTRODUCTION

In recent years, as people have become more aware and conscious about health issues, the demand for functional foods has risen drastically. Thus, research on the nutrient-rich but neglected plants is gaining more importance to ensure global food security and to satisfy the nutritional need. *Moringa oleifera* is exceptionally nutritious tree, and almost its every part can be utilized for food or other beneficial applications, so it is considered as "superfood" or "miracle tree". Its leaves contain high amount of protein, fiber, fats, minerals (calcium, magnesium, phosphorus, potassium, copper, iron and zinc), carotene and vitamin C (Oyeyinka and Oyeyinka, 2016). It is also rich in α-linoleic acid, essential amino acids, beneficial phytochemicals and glycoside compounds (Daba, 2016). These phytochemicals have various biological activities, including antioxidant, anti-carcinogenic, immunomodulatory, anti-diabetic, anti-atherogenic, and hepatoprotective functions and the regulation of thyroid status, potent anticancer and hypertensive activity and recommended for various medicinal uses. Moringa leaves have extensive use in pharmaceutical, nutraceutical and cosmetic industries but their main market is of health products which is very promising for new research and developmental activities. Fresh green leaves used for culinary and medicinal purposes are highly perishable by nature and also not available in sufficient quantity throughout the year as most of the yields are seasonal, thus, to preserve leaves for a longer duration and to ensure their easy availability for off-season use without considerable deterioration in nutrient levels, drying is important. Dried leaves are generally reported to have active nutrient levels that are three to four times higher than that of fresh leaves (Navale *et al.,* 2014). Studies indicated that moringa leaf powder (MLP) had good nutritional value, but it is not yet customized and properly consumed. Supplementation of MLP with different products can be a better choice as it significantly improved the nutritional quality especially in micro and macro nutrients. It can be added to various value-added food products for nutrient fortification. Several researchers have developed various products viz., stiff dough 'Amala', cereal gruel, bread, biscuits, yoghurts and cheese, cake and soup (Oyeyinka and Oyeyinka, 2016), herbal tea (Fombang and Saa,

2016), ready-to-eat snack product (Devisetti *et al.,* 2016).

Traditional snacks available in India are much more nutritious than those commonly available in the market (Pathania *et al.,* 2017). *Khakhra* is one of the famous traditional Gujarati snacks commonly prepared from wheat flour and most preferred food item among all age groups. *Khakhras* are very thin crackers, crispy, crunchy, mouth-watering tasty nutritious and very light in weight consumed either as ready-to-eat snack or in breakfast. They are usually eaten with tea, coffee, chutney, pickles, butter, ghee, topped vegetable, cheese or yoghurt. In recent times, it has gained popularity in various parts of the country as well. As these do not require any further processing during consumption, have a long shelf life, light in weight and convenient to be carried during travelling. These are uniquely hand-made and roasted products, with different varieties available in the market, however, most of them do not possess any additional health benefits. Availability of such snack with addition of MLP may enhance the nutritional value and provide health benefits. It will further provide consumers a new alternative to traditional *khakhra*. Thus, keeping this in view, an effort was made in the present study to develop *masala khakhras* incorporating MLP which may be nutritionally rich and possess health promoting properties. It was further investigated for nutritional composition, total phenolic and flavonoids content, antioxidant activity, colour and texture analysis.

MATERIALS AND METHODS

The moringa leaves were collected from the Campus of Guru Jambheshwar University of Science and Technology, Hisar, Haryana, India. The leaves and stems were separated. Then, fresh, green and undamaged leaves were sorted. Bruised, discoloured, decayed, wilted and insect-pest and diseases infested leaves were discarded. The selected leaves were washed thoroughly with distilled water for removing dirt and impurities from surface of leaves and transferred to stainless steel sieve and kept for 30 min to drain out surface water. The leaves were blanched in hot water at optimized temperature and time (84.6°C for 58.4 sec) using response surface methodology with 0.5% KMS solution and dried in freeze dryer (Shobhit *et al.*, 2022). Then, the dried leaves were ground to fine powder and stored in zip lock polyethene bags. Raw materials for *masala khakhra* preparation were procured from the local market of Hisar. All chemicals used for this study were of analytical grade and purchased from Himedia Laboratories, India.

Moringa leaves powder fortified *masala khakhras* were prepared by supplementing MLP at 2.5, 5.0, 7.5 and 10.0% levels in whole wheat flour. *Masala khakhras* prepared by whole wheat flour (100%) served as control. The other ingredients of recipe such as olive oil, red chilli powder, turmeric powder, cumin, salt, carom seeds (*ajwain)*, *garam masala* powder, dried fenugreek leaves (*kasoori methi)* and water were added as 10 ml, 2%, 2%, 2%, 2%, 1%, 0.5%, 1% and 70 ml, respectively, and were kept constant for all five combinations. All the ingredients were mixed and kneaded to make stiff dough. Dough resting was done for a time period of 30 min. Dough was divided in equal parts and round thin sheets were prepared and roasted on *khakhra* maker from both sides.

The developed *masala khakhras* were oven-dried at 55-60°C to a constant weight, ground in an electric grinder to a fine powder, stored in air-tight polythene sheets and were analyzed for proximate composition (moisture, crude protein, crude fat, ash and crude fibre) by employing the standard method of AOAC (2012). The carbohydrate content was calculated as a difference between total sum of moisture, crude protein, crude fat, ash and crude fibre from 100. The energy value was calculated by multiplying the mean values for the crude fat, crude protein and total carbohydrates by 4, 9 and 4 Kcal/g, respectively (Mouminah, 2015).

The colour analysis of *masala khakhra* was determined using CR-400 chroma meter that was calculated in terms of L*, a*, b* which represents light-dark spectrum with a range from 0 (black) to 100 (white), the green-red spectrum with a range from -60 (green) to +60 (red) and the blue-yellow spectrum with a range from -60 (blue) to +60 (yellow), respectively. Measurements were taken using CIE Illuminant C and the instrument was calibrated using a standard white tile reflector. Where, L* was degree of lightness to darkness, a* was degree of redness to greenness and b* was degree of blueness to yellowness.

The texture analysis of *masala khakhras* i.e. hardness was measured by texture analyzer. The analyzer was performed on compression mode with pre-test speed, test-speed, post-test speed, distance, trigger force, and points per second of 1.00 mm/s, 2.00 mm/s, 10.00 mm/s, 5.0 mm, 5.0 g and 400, respectively. The probe used for this test was three-point bend ring.

To determine the total phenolics, total flavonoids and DPPH radical scavenging activity extraction of samples was carried out in methanol. Total phenolic content was determined using the Folin-Ciocalteu reagent. The antioxidant activity was assessed on the basis of the radical scavenging effect of the stable 1, 1-diphenyl-2-picrylhydrazyl (DPPH)-free radical activity. The total flavonoids content was assayed by the aluminum chloride colorimetric method.

The developed *masala khakhras* were subjected to sensory evaluation with respect to colour, appearance, aroma, texture, taste and overall acceptability on 9-Point Hedonic Rating Scale by 15 expert panelists.

The data were statistically analyzed in a completely randomized design using analysis of variance in OPSTAT software to test the significant differences among treatments.

RESULTS AND DISCUSSION

The data on proximate composition, energy and hardness of MLP powder supplemented *masala khakhra* have been presented in Table 1.

The moisture content of control and MLP supplemented *masala khakhra* varied significantly. *Masala khakhra* supplemented with 10% MLP (6.67%) had highest moisture content as compared to control (5.84%). The results are in agreement with those reported by Solanke *et al.* (2018) for wheat flour, buckwheat flour and garden cress seeds flour *khakhra* and Sindhu and Prakash (2021) for millet-based *khakhra*s and Shanker *et al.* (2019) for *khakhra* enriched with purslane leaves.

The protein content of *masala khakhra* increased significantly after supplementation with 5 to 10% MLP as compared to control due to high protein content of moringa leaves. The maximum protein content was found in 10% MLP supplemented *masala khakhra* (10.33%) and minimum in control (8.87%). Similar results were reported by Solanke *et al.* (2018) for wheat flour, buckwheat flour and garden cress seeds flour *khakhra*, whereas higher protein content was reported by Sindhu and Prakash (2021) for millet-based *khakhra*s.

Supplementation of MLP from 5 to 10% significantly increased the fat content of *masala khakhra* as compared to control due to high fat content of moringa leaves. The highest fat content was observed in 10% MLP supplemented *masala khakhra* (10.44%) as compared to control (9.21%). Similar results were reported by Sindhu and Prakash (2021) for millet-based *khakhra*s, while lower fat content was reported by Shanker *et al.* (2019) for *khakhra* enriched with purslane leaves.

The ash content of *masala khakhra* increased significantly after supplementation with 5 to 10% MLP as compared to control due to high ash content of moringa leaves. The ash content was maximum in 10% MLP supplemented *masala khakhra* (4.42%) as compared to control (3.36%). The findings of present study are comparable to those reported by Solanke *et al.* (2018) for wheat flour, buckwheat flour and garden cress seeds flour *khakhra* and Sindhu and Prakash (2021) for millet-based *khakhra*s.

The fibre content of *masala khakhra* increased

Table 1. Proximate composition, energy and hardness of *masala khakhra*

Types of *masala khakhra*	Proximate analysis (%)						Energy (Kcal/100 g)	Hardness (N)
	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate		
WF (100%)-Control	5.84^{c}	8.87^{b}	9.21^{c}	3.36^{c}	1.43^{e}	71.30^{a}	403.59^{a}	11.86^{c}
WF: MLP (97.5 : 2.5)	6.16^{b}	9.08^{b}	9.37^{bc}	3.53^{c}	1.62^{d}	70.23^{ab}	401.53^{b}	16.92^{c}
WF: MLP (95 : 5.0)	6.25^{b}	9.47^{b}	9.79^{b}	3.82^{b}	1.83^{c}	68.84^{b}	401.32^{b}	19.09^{b}
WF: MLP (92.5 : 7.5)	6.44^{ab}	9.91^{ab}	10.09^{ab}	4.03^{b}	2.05^{b}	67.47^{b}	400.38^{b}	20.99^{a}
WF: MLP (90 : 10)	6.67^{a}	10.33^{a}	10.44^{a}	4.42^{a}	2.30^{a}	65.84^{c}	398.66^{c}	22.13^{a}
S. Em±	0.08	0.19	0.14	0.08	0.05	0.46	0.45	0.55
C. D. (P≤0.05)	0.26	0.61	0.45	0.26	0.16	1.47	1.45	1.76

Values are mean of three independent determinations WF: Wheat flour and MLP: Moringa leaves powder.

significantly with the level of supplementation of MLP from 2.5 to 10% as compared to control due to more fibre content of moringa leaves. The fibre content was maximum in 10% MLP supplemented *masala khakhra* (2.30%) as compared to control (1.43%). The results are in agreement with those of Shanker *et al.* (2019) for *khakhra* enriched with purslane leaves.

The carbohydrate content (71.30%) of control *masala khakhra* was maximum. A significant decrease was observed in the carbohydrate content of *masala khakhra* after supplementation with 5 to 10% MLP and ranged from 68.84 to 65.84%. The results obtained in the present study are within the range as reported by Solanke *et al.* (2018) for wheat flour, buckwheat flour and garden cress seeds flour *khakhra* and higher than Sindhu and Prakash (2021) for millet-based *khakhra*s. The energy was maximum in control *masala khakhra* (403.59 Kcal/100 g) which decreased significantly after supplementation with MLP from 2.5 to 10%. Among MLP supplemented *masala khakhra* the energy content was highest in 2.5% (401.53 Kcal/100 g) and lowest in 10% (398.66 Kcal/100 g).

The hardness of control *masala khakhra* was 11.86 N which increased significantly with the supplementation of MLP from 16.92 N (2.5%) to 22.13 N (10%). Moringa supplemented *masala khakhra* was slightly hard and less crispy as compared to wheat flour *masala khakhra* (control). Shanker *et al.* (2019) reported hardness in the range of 10.95-13.34 N for *khakhra* enriched with purslane leaves.

The data in respect of colour of MLP supplemented *masala khakhra* have been presented in Table 2. A significant difference was observed in the L*, a* and b* values of *masala khakhra*. Supplementation of MLP significantly decreased the L*, a* and b* values of *masala khakhra*. The L* (39.09), a* (7.39) and b* (22.44) values of 10% MLP supplemented *masala khakhra* were lowest, whereas highest values were found in control *masala khakhra* (57.72, 14.44 and 34.79). The L* value depicts the lightness index and ranges from 0 to 100. The control *masala khakhra* had higher L* values which meant that they were lighter in colour and moringa supplemented *masala khakhra* had lower L* value indicating darkness. The a* values ranged from -60 (greenness) to +60 (redness). The b* values varied from -60 (blueness) to +60 (yellowness). All *masala khakhra*s had the positive a* and b* values, therefore slightly brownish and yellowish in colour. All values were close to zero thus were not highly red or green and yellow or blue. The decrease in a* and b* values of moringa supplemented *masala khakhra* indicated increase in greenness and decrease in yellowness and brownishness.

Table 2. Colour analysis of *masala khakhra*

Types of *masala khakhra*	Colour values		
	L*	a*	b*
WF (100%)-Control	57.72[a]	14.44[a]	34.79[a]
WF: MLP (97.5 : 2.5)	50.81[b]	13.72[a]	32.37[b]
WF: MLP (95 : 5.0)	46.88[c]	11.59[b]	29.99[c]
WF: MLP (92.5 : 7.5)	43.60[d]	10.04[c]	26.94[d]
WF: MLP (90 : 10)	39.09[e]	7.39[d]	22.44[e]
S. Em±	0.68	0.33	0.52
C. D. (P≤0.05)	2.16	1.06	1.66

Values are mean of three independent determinations, WF: Wheat flour and MLP: Moringa leaves powder.

The observations for total phenolic content (TPC), total flavonoid content (TFC) and DPPH free radical scavenging activity (DPPH) of MLP supplemented *masala khakhra* are shown in Fig. 1. The total phenolic content, total flavonoid content, and antioxidant activity of *masala khakhra*s ranged from 3.38-4.49 mg/g, 5.56-6.33 mg/g and 5.34-7.34%, respectively. As evident from Fig. 1, slight increase in total phenolic content, total flavonoid content and DPPH radical scavenging activity was observed with increasing level of MLP. The increase in TPC, TFC and DPPH was due to presence of high amount of phenolic acids viz., gallic acid, chlorogenic acid, caffeic acid, ellagic acid, ferulic acid and flavonoids such as quercetin, kaempferol. Similar findings were reported by Jayawardana *et al.* (2015) as antioxidant potential of chicken sausages increased with incorporation of drumstick leaves.

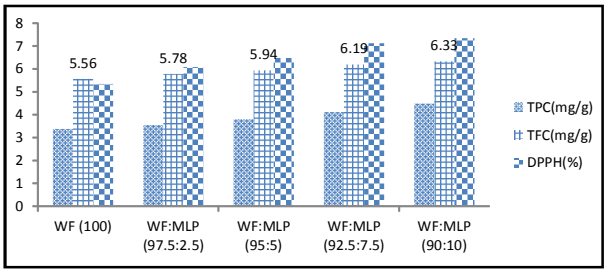

Fig. 1. Phytochemical composition of *masala khakhras*. WF: Wheat flour and MLP: Moringa leaves powder.

Data regarding sensory characteristics of MLP supplemented *masala khakhra* are presented in Fig. 2. The *masala khakhra* containing 100% wheat flour had maximum mean scores for all the sensory parameters i.e. colour (8.0), appearance (8.0), aroma (8.1) which fell in the category of 'liked very much', while, texture (7.8), taste (7.9) and overall acceptability (7.96) fell in the category of 'liked moderately'. Supplementation of MLP significantly decreased the organoleptic scores. *Masala khakhra* prepared with the incorporation of 5% MLP was found to be best in terms of all sensory characteristics i.e. appearance, aroma, texture and taste with mean scores of 7.8, 7.8, 7.7 and 7.8, respectively, except colour (7.7) followed by 2.5% MLP with mean scores of 7.9, 7.8, 7.7. 7.5 and 7.5 for colour, appearance, aroma, texture and taste as compared to other supplementation levels and fell in the category of 'liked moderately'. The mean scores of colour (6.7), appearance (6.8), aroma (6.8), texture (7.1) and taste (6.0) of *masala khakhra* made by supplementation of 10% MLP were lowest and 'liked slightly' by the judges. The overall acceptability score was 7.76 for 5% MLP supplemented *masala khakhra* followed by 7.68 and 7.02 for 2.5 and 7.5%, respectively, which were 'liked moderately' by the judges, while it was 6.68 for 10% supplementation level which fell in the category of 'liked slightly'. Therefore, supplementation of MLP up to 5% level was found acceptable in *masala khakhra*. Similar results were also reported by Mamta *et al.* (2017) who reported that MLP up to 5% level was most acceptable in *khakhra*. Solanke *et al.* (2018) developed *khakhra* from wheat flour, buckwheat flour and garden cress seeds flour and found them acceptable. Mahalakshmi and Pattan (2021) prepared *khakhra* by incorporating amaranth leaves powder and found 5% level most acceptable.

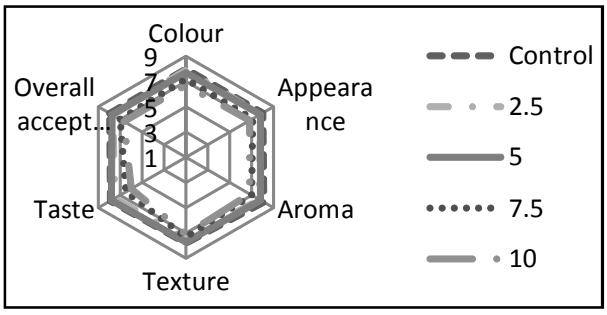

Fig. 2. Sensory analysis of *masala khakhra.*

CONCLUSION

It may be concluded from the present study that moringa leaves powder has potential in fortification of foodstuffs. From the sensory analysis, it was revealed that moringa leaves powder up to 5% incorporation was acceptable in *masala khakhra*. Better taste and superior nutritive value with high polyphenols, flavanoids and antioxidant activity of moringa leaves powder supplemented *masala khakhra* justify its high consumer acceptability. Therefore, it is necessary to popularize this traditional ready-to-eat snack as a functional food among all age groups.

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