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Development of Iron Rich Til Ladoo Incorporated with *Moringa olifera* Leaves Powder

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ABSTRACT

Iron deficiency anaemia is a primary issue around the globe, particularly among women and children in developing countries, causing a significant risk to overall wellbeing. Therefore, an attempt was made to develop iron-rich ladoo by incorporating *Moringa olifera* leaf powder (MOLP) at 0, 5, 10 and 15 per cent and assess for sensory acceptability, nutritional quality, anti-nutrient and antioxidant properties. The result shows that 5 per cent MOLP incorporated in Til ladoo was the most acceptable prototype. The protein, energy, dietary fibre, calcium, iron, β-carotene, thiamine, vitamin C, riboflavin, pyridoxine and vitamin B_{12} increased significantly ($p < 0.05$) with the incorporation of 5 per cent MOLP, whereas fat, energy and zinc decreased. The anti-nutrients oxalate, phytate and lectin decreased significantly ($p < 0.05$), while tannin and trypsin inhibitors increased. The radical scavenging activity of 5 per cent MOLP incorporated Til ladoo was significantly higher than the Control Til ladoo.

Keywords : Til ladoo, *Moringa olifera* leaf powder, Black sesame seeds, Iron-rich foods, Sensory characteristics

ANAEMIA is a severe health issue that causes social, developmental and medical challenges around the globe. About 40 per cent children 6-59 months of age, 37 per cent pregnant women and 30 per cent women 15-49 years of age globally are anaemic (WHO, 2023). Iron deficiency anaemia (IDA) has prevailed worldwide for several decades. It broadly affects the health condition of all age group particulary the pre-schoolers, children, adolescent girls and pregnant and lactating women (Bathla and Arora, 2022). In most cases, anaemia is due to iron deficiency, insufficient consumption of foods rich in iron, malabsorption, intestinal parasites and hemorrhage (Okuturlar *et al.,* 2016).

Ladoo is one of the most versatile and popularly consumed traditional Indian sweets. Value-added nutrient-dense laddoo has also been quite popular in recent years as ladoos are liked and preferred by many as their snacks. Til ladoo prepared with Black sesame seeds, roasted Bengal gram and Jaggery was used as a basic ingredient and *Moringa olifera* leaves powder was incorporated in the present study. Sesame, an ancient oil crop, is well known for its versatility and high nutrient content. Research indicates that both sesame seeds and sesame oil boast a higher concentration of phytochemicals and more significant nutritional benefits (Wei, 2022). Sesame seeds also boast significant levels of iron and zinc, contributing to their nutritional value (Kurt, 2018). Moringa leaves are rich in various micronutrients, including β-carotene, thiamin (B_1), riboflavin (B_2), niacin (B_3), iron, magnesium, calcium, phosphorus and zinc. Moringa is an excellent source of iron, a nutrient often lacking in most plant-based diet (Loa, 2021). Various studies have explored incorporating moringa leaf flour in different ranges of food products due to its potential health benefits, exploring different processing methods to ensure optimal consumer acceptance. Therefore, this study aims to develop iron rich Til ladoo incorporating with *moringa olifera* leaves powder and to assess its quality.

Material and Methods

Procurement and Processing of Raw Materials

The ingredients used to prepare Til ladoo were black sesame, roasted bengal gram dhal, ground nut, cucumber seeds, jaggery and *Moringa olifera* leaves powder. The black sesame was collected from the local farmer of Langting town in Dima Hasao District, Assam. Roasted Bengal gram dhal, ground nut, cucumber seeds and jaggery were obtained from the local market of Guwahati. *Moringa olifera* leaves were collected from Guwahati City, Assam.

The sesame seeds were manually cleaned for impurities like stones and yellowed seeds, washed thoroughly in cleaned water using a strainer with a little rubbing to facilitate the removal of the seed coat and then shade-dried for 12 hours in a well-ventilated area and then stored in an airtight container. The roasted bengal gram dhal, ground nut and cucumber seeds were also manually checked and cleaned for impurities. The ground nut and cucumber seeds were roasted in a thick bottom pan for 3-4 minutes and stored in an airtight container separately. *Moringa olifera* leaves were separated from the stem, yellowed leaves, insect-infested leaves and then washed thoroughly with clean water and drained water from the leaves and shade dried on a flat circular bamboo tray for two days in a well-ventilated room till it was thoroughly dried and ground into powder in a mixie grinder, sieved in a fine wire mesh sieve (60 mesh size-0.25 mm) and stored in an airtight container for further use.

Standardisation of Til Ladoo for Ingredients

Black sesame seeds and jaggery are the basic ingredients commonly used to prepare Til ladoo in Assam. To add value to this basic Til ladoo, other ingredients like groundnut, cucumber seeds and roasted bengal gram dhal were incorporated alongside sesame seeds, replacing 10 per cent of sesame seeds as shown in Table 1. Black sesame seeds are roasted separately in a low flame, stirring occasionally till the sesame seeds pop and roasted aroma is achieved and cooled. Groundnut and cucumber seeds are also roasted separately and cooled. Groundnut is crushed once it is cooled. Roasted bengal gram was used as it is. The jaggery is heated in low heat with a tablespoon of water till it reaches a soft ball stage. The heat is turned off, all the other ingredients are added to the jaggery solution and a ladoo ball is formed while still hot.

Table 1

Standardization of Til ladoo

Ingredients	TL-1	TL-II	TL-III	TL-IV
Black sesame seeds (g)	50	45	45	45
Groundnut (g)	-	5	-	-
Roasted Bengal gram dhal (g)	-	-	5	-
Cucumber seeds (g)	-	-	-	5
Jaggery	50	50	50	50

Preparation of MOLP Incorporated Sesame Ladoo

Using the best organoleptically accepted standardised Til ladoo, three variations with the addition of 5, 10 and 15 per cent of *Moringa olifera* leaves powder were prepared as shown in Table 2, to select the organoleptically best-accepted incorporation of Til ladoo. The sesame seed was roasted in a thick bottom pan for 10 minutes on a low-medium flame and then cooled. Jaggery was melted in a thick bottom pan. The roasted sesame seed, roasted Bengal gram dhal and *Moringa olifera* leaves powder (MOLP) were added to the jaggery syrup and mixed with a wooden ladle and laddoos were made while still hot. The prepared ladoos were cooled at room temperature and stored in an LDPE package.

Table 2

Composition of Til ladoo incorporated with *Moringa olifera* leaves powder

Ingredients	TLC	TLV-I	TLV-II	TLV -III
Black sesame seeds (g)	45	40	35	30
Roasted Bengal gram dhal (g)	5	5	5	5
Jaggery (g)	50	50	50	50
Moringa leaves powder (g)	-	5	10	15

Organoleptic Evaluation

The prepared ladoos were evaluated for their organoleptic attributes by 20 semi-trained panel members from Handique Girls' College Guwahati. A 9-point hedonic scale depicting sensory acceptance as 1-dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neither like nor dislike, 6-like slightly, 7-like moderately, 8-like very much, 9-like extremely (Lim, 2011) was used for this purpose. The panellists were asked to evaluate the ladoos and score the ladoo with reference to hedonic scale for their attributes *i.e.,* appearance, texture, colour, flavour and overall acceptability to find out the best-accepted standardised Til ladoo as well as the best-accepted level of incorporation of *Moringa olifera* leaves powder (MOLP) incorporation. Based on the organoleptic evaluation data, the highest recorded score was finalised as the accepted product, which was further subjected to nutrient analysis and anti-nutrient analysis.

Nutrient Analysis

Moisture, ash content, protein, fat and dietary fibre were determined by the AOAC method (AOAC, 1999). Carbohydrate was calculated by differential method *i.e.,*

Carbohydrate % = 100 - (% Fat + % Protein + % Ash + % Moisture)

The Energy/Calories was calculated by

Energy = (Total Fat x 9) + (Protein x 4) + (Carbohydrate x 4)

Thiamine, riboflavin and niacin were determined by the AOAC method (AOAC, 1999). Other nutrients, namely, carotene, vitamin C, pyridoxine, vitamin B_{12}, folic acid, iron, calcium, phosphorous, iodine and zinc, were assessed using the procedures recommended by Raghuramulu *et al*., (2003).

Anti-nutrient Analysis

Phytate was analysed according to Haug and Lantzech (1983) method. Lectin was extracted in a buffer with salt precipitation and estimated by Lowry method (1951). The tannins were analysed by Folin - Ciocalteu method as suggested by Tambe and Bambar (2014). Oxalate was determined by titrating against boric acid solution (AOAC, 1999). Trypsin inhibitor was analysed as suggested by Marzo *et al*., (1998).

DPPH Assay

The free radical scavenging activity of the extracts was determined by using DPPH assay as described by Wright *et al.* (2017). The decrease in the absorbtion of the DPPH solution after the addition of an antioxidant was measeured at 517 nm.

Statistical Analysis

The data obtained were analysed for descriptive analysis for mean and standard deviation. The result for sensory analysis was analysed using One-way Analysis of variance (ANOVA) and then subjected to Tukey test of mean separation at $p< 0.05$, while an Independent t-test was used to analyse the significance ($p < 0.05$) between the nutrients, anti-nutrient of TLC and the highly accepted product. All the analysis was done using IBM SPSS 21 software.

Results and Discussion

Organoleptic Evaluation

The prepared Til ladoos using different ingredients were evaluated based on their organoleptic characteristics and the finding are summerized in Table 3.

The results shows that for all the parameter TL-III ladoo shows that higher score with 8.20 ± 0.83 for appearance and colour, 8.10 ± 0.85 for flavour, 7.50 ± 0.89 for texture, 7.50 ± 0.82 for taste and 7.65 ± 0.88 for overall acceptability. Although the score for TL-III was highest in term of value yet there was no statistical differences between the variation which shows that all the variation was accepted well by the penellist. As TL-III being the higest scorer, it was considered as a control varaiotion for further studies *i.e.,* incorporation of MOLP.

Moringa olifera leaves powder (MOLP) incorporated Til ladoo was subjected to Organoleptic evaluation

TABLE 3

Organoleptic evaluation for standardization of Til Ladoo

Variation	Appearance and colour	Flavour	Texture	Taste	Overall acceptability
TL-I	8.05 ± 0.89 [a]	7.90 ± 0.79 [a]	7.05 ± 1.00 [a]	7.15 ± 0.93 [a]	7.25 ± 0.91 [a]
TL-II	8.10 ± 0.85 [a]	7.85 ± 0.81 [a]	7.30 ± 0.98 [a]	7.30 ± 0.98 [a]	7.45 ± 0.83 [a]
TL-III	8.20 ± 0.83 [a]	8.10 ± 0.85 [a]	7.50 ± 0.89 [a]	7.50 ± 0.82 [a]	7.65 ± 0.88 [a]
TL-IV	8.15 ± 0.81 [a]	8.05 ± 0.83 [a]	7.45 ± 0.94 [a]	7.50 ± 0.95 [a]	7.55 ± 0.88 [a]

Values are presented as means ± standard deviation. Treatment values within columns with different letter are significantly different at p ≤ 0.05, as determined by the Tukey test

and the results are depicted in Table 4. The result showed a significant difference at $p<0.05$ between the TLC and MOLP incorporated Til ladoo for all the sensory attributes.

The incorporation of MOLP decreases the acceptability of the Til ladoo. The appearance and colour of the Til ladoo ranges from 8.22 ± .76 in TLC to 6.40 ± .64 in TLV-III, which is due to the loss of lustre in the ladoo with the addition of MOLP and an increase in its volume make a ladoo appear duller in appearance and colour. The score in the flavour ranges from 8.16 ± .74 in TLC to 6.34 ± .59 in TLC-III. The decrease in the score may be attributed to the strong flavour of the MOLP, which is not characteristic of the commonly consumed Til ladoo, which may have led to grading it as a low score. The texture ranges from 7.64 ± .85 in TLC to 4.84 ± .51 in TLV-III, as adding MOLP leads to hardening. The score for the taste ranges from 7.68 ± .84 in TLC to 5.38 ± .67 in TLV-III, which may be again attributed to the distinct flavour and bitterness of leaf powder due to high phenolic and flavanoid compounds (Sankhalkar and Vernekar, 2016), which many people do not prefer. Similarly, when herbs with high phenolic and flavanoid compounds was incorporated in a flour mix, the acceptabily decreases (Rani and Jamuna, 2013). The overall acceptability of the product ranges from 7.66 ± .85 in TLC to 5.18 ± .87 in TLV-III. Similar studies with 5 per cent, 10 per cent and 15 per cent incorporation of MOLP on millet RTE snacks show the same result where TLC had the highest score in all attributes and 5 per cent incorporated snack was the only acceptable treatment (Mounika *et al.*, 2021). Other studies with MOLP incorporation shows that 1 per cent MOLP and Tulsi being acceptable in cookies, 8 per cent MOLP incorporated in cakes and 10 per cent in cookies were the most acceptable and the sensory acceptability

TABLE 4

Organoleptic evaluation of different variations of Til ladoo

Variation	Appearance and colour	Flavour	Texture	Taste	Overall acceptability
TLC	8.22 ± 0.76 [a]	8.16 ± 0.74 [a]	7.64 ± 0.85 [a]	7.68 ± 0.84 [a]	7.66 ± 0.85 [a]
TLV -I	8.02 ± 0.74 [a]	7.82 ± 0.52 [b]	7.02 ± 0.74 [b]	7.14 ± 0.67 [b]	7.14 ± 0.61 [b]
TLV-II	6.74 ± 0.83 [b]	7.08 ± 0.53 [c]	5.48 ± 0.79 [c]	5.94 ± 0.62 [c]	6.02 ± 0.59 [c]
TLV-III	6.40 ± 0.64 [bc]	6.34 ± 0.59 [d]	4.84 ± 0.51 [d]	5.38 ± 0.67 [d]	5.18 ± 0.87 [d]

Values are presented as means ± standard deviation. Treatment values within columns with different letter are significantly different at p ≤ 0.05, as determined by the Tukey test decreases significantly with increase in MOLP concentration (Alam *et al.,* 2014; Kolawole *et al.,* 2013 and Dachana *et al.,* 2010). Therefore, based on the organoleptic scores of the incorporation of MOLP, TLV-I was found to be the most acceptable and was chosen for further study.

Nutritional Profile of *Moringa olifera* Leaves

The Nutritional profile of *Moringa olifera* leaves powder (MOLP) and Fresh *Moringa olifera* leaves (FMOL) is depicted in Table 5.

The proximate composition analysis of Fresh *Moringa oleifera* Leaves (FMOL) and *Moringa oleifera* Leaves Powder (MOLP) revealed substantial differences. FMOL had a high moisture content of 73.4 per cent, whereas MOLP exhibited effective dehydration with 4.7 per cent. MOLP showed a significant increase in energy content from 101 Kcal in FMOL to 373 Kcal, emphasising nutrient concentration. Carbohydrate content rose from 15.5 g in FMOL to 57.4 g in MOLP. Fat content increased from 1.4 g in FMOL to 4.8 g in MOLP. Protein content notably rose from 6.9 g in FMOL to 25.1 g in MOLP, emphasising amino acid concentration. Dietary fibre content significantly increased from 5.5 g in FMOL to 21.4 g in MOLP, highlighting its potential for digestive health.

Table 5

Nutrient profile of *Moringa olifera* leaves powder (MOLP) and Fresh *Moringa olifera* leaves (FMOL)

Nutrients	MOLP	FMOL
Moisture (%)	4.7 ± 0.06 [a]	73.4 ± 0.25 [b]
Energy (Kcal)	373 ± 2.55 [a]	101 ± 1.48 [b]
Carbohydrate (g)	57.4 ± 0.2 [a]	15.5 ± 0.15 [b]
Fat (g)	4.8 ± 0.15 [a]	1.4 ± 0.06 [b]
Protein (g)	25.1 ± 0.1 [a]	6.9 ± 0.12 [b]
Dietary fibre (g)	21.4 ± 0.06 [a]	5.5 ± 0.10 [b]
β-carotene(mg)	23.6 ± 0.15 [a]	6.5 ± 0.15 [b]
Thiamine (mg)	0.29 ± 0.02 [a]	0.08 ± 0.01 [b]
Riboflavin (mg)	0.21 ± 0.01 [a]	0.05 ± 0.01 [b]
Niacin (mg)	3.8 ± 0.06 [a]	1.1 ± 0.12 [b]
Pyridoxine (mg)	3.1 ± 0.06 [a]	0.92 ± 0.02 [b]
Folate (µg)	134 ± 1.0 [a]	40 ± 0.58 [b]
Vitamin C (mg)	720 ± 2.52 [a]	21 ± 1.53 [b]
Calcium (mg)	1750 ± 2.0 [a]	460 ± 1.15 [b]
Iron (mg)	24.2 ± 0.06 [a]	7.5 ± 0.06 [b]
Zinc (mg)	5.1 ± 0.1 [a]	1.4 ± 0.15 [b]

Values are the means of triplicate measurements ± standard deviation. Values in rows with different letter are significantly different ($p < 0.05$)

The vitamin and mineral analysis of Fresh *Moringa oleifera* Leaves (FMOL) and *Moringa oleifera* Leaves Powder (MOLP) demonstrates a notable increase concentration of essential micronutrients during the dehydration process. MOLP exhibited enhanced levels of vitamin A (23.6 mg), thiamine (0.29 mg), riboflavin (0.21 mg), niacin (3.8 mg), pyridoxine (3.1 mg), folate (134 µg) and vitamin C (720 mg) compared to their respective values in FMOL. Additionally, MOLP displayed increased mineral content, including calcium (1750 mg), iron (24.2 mg) and zinc (5.1 mg) compared to FMOL. These findings underscore the potential of MOLP as a concentrated source of vitamins and minerals with diverse health benefits.

Nutritional Composition of Til Ladoo

The nutritional composition of TLV-I, *i.e.,* Til ladoo with 5 per cent MOLP, was found to be the most acceptable in terms of its organoleptic score. Therefore, the best accepted Til ladoo variant (TLV-I) was analysed for nutritional composition and compared with the control Til ladoo- TLC, which is presented in Table 6.

The moisture content in TLV-I ladoo was 4.3 per cent while that of TLC was 4.1 per cent, showing no significant difference at $p < 0.05$. The fat content in TLV-I ladoo was 16.18 g, significantly lower than 18.7 g in TLC. This higher fat content in TLC ladoo can be attributed to the higher fat content in sesame seeds. The protein in TLV-I ladoo was 17.2 g compared to 16.1 g in the TLC ladoo. The significant increase protein in TLV-I could be due to the higher percentage of protein in the MOLP. Although ash content in TLV-I was 3.7 g which is more than

TABLE 6

Nutrient content of TLV-I and TLC ladoo

Parameter	TLC	TLV-I
Moisture (%)	4.1 ± 0.06 [a]	4.3 ± 0.20 [a]
Fat (g)	18.7 ± 0.31 [a]	16.8 ± 0.44 [b]
Protein (g)	16.1 ± 0.20 [a]	17.2 ± 0.26 [b]
Ash (g)	3.6 ± 0.10 [a]	3.7 ± 0.10 [a]
Carbohydrate (g)	57.5 ± 0.61 [a]	58 ± 0.66 [a]
Energy (Kcal)	462.7 ± 1.11 [a]	452 ± 2.18 [b]
Dietary fibre (g)	2.3 ± 0.10 [a]	3.1 ± 0.10 [b]
Calcium (mg)	170 ± 2.65 [a]	196 ± 4.58 [b]
Iron (mg)	11.5 ± 0.26 [a]	12.8 ± 0.20 [b]
Zinc (mg)	8.2 ± 0.20 [a]	7.1 ± 0.17 [b]
β-carotene (mg)	2.5 ± 0.10 [a]	3.3 ± 0.10 [b]
Thiamine (mg)	0.41 ± 0.04 [a]	0.45 ± 0.02 [a]
Vitamin C (mg)	1.3 ± 0.10 [a]	1.8 ± 0.10 [b]
Riboflavin (mg)	0.12 ± 0.02 [a]	0.21 ± 0.02 [b]
Niacin (mg)	2.7 ± 0.10 [a]	2.9 ± 0.20 [a]
Pyridoxine (mg)	0.38 ± 0.04 [a]	0.5 ± 0.03 [b]
Vitamin B_{12} (μg)	0.1 ± 0.03 [a]	0.18 ± 0.03 [b]
Folate (μg)	45 ± 3.61 [a]	52 ± 4.58 [a]

Values are the means of triplicate measurements ± standard deviation. Values in rows with different letter are significantly different ($p < 0.05$)

3.6 g in TLC, no significant difference was observed between the two. There was also no significant difference among the ladoos in terms of their carbohydrate content, which was 58.0 g for TLV- I ladoo and 57.6 g for TLC ladoo. The total energy of the TLV- I ladoo was 452 KCal, which was significantly lower than that of the TLC ladoo, which was 463 Kcal. This decrease is basically because 5 per cent of the sesame is replaced with MOLP in TLV-I ladoo, as sesame is rich in fat and energy. The dietary fibre content was 3.1 g in TLV-I ladoo and 2.3 g in TLC ladoo; this significant difference is due to more fibre in the MOLP.

Moringa Olifera leaves powder (MOLP) is rich in minerals like calcium and iron. Therefore, it was observed that there was a significantly higher amount of calcium content in TLV-I ladoo, which was 196 mg, as compared to 170 mg in TLC. Similarly, Iron increases significantly with the incorporation of MOLP. The TLV-I ladoo has 12.5 mg, while TLC ladoo has 11.5 mg. MOLP leaves are a rich source of iron (25-28 mg/100g) (Gopalakrishnan, 2016); therefore, incorporating Til ladoo with MOLP enhances its iron content. MOLP-incorporated products have also been shown to be effective in improving haemoglobin. It was also observed that iron and calcium content increases in the MOLP-incorporated bread (Sengev *et al.,* 2013). Iron and calcium also increased in the MOLP-incorporated utappam, idly and snacks (Gupta *et al.,* 2017 and Zungu *et al.,* 2020). Zinc content in TLV-I ladoo was 7.1 mg, significantly lower than 8.2 mg in TLC, which may be accredited to the higher Zinc content in Sesame seeds.

Moringa olifera is also a powerhouse of vitamins. Therefore, the incorporation of MOLP increases the vitamin content of a product. It is observed that the Vitamin A content of TLV-I ladoo was 3.3 μg, which was significantly higher than that of TLC ladoo with 2.5 μg. Thiamine content in TLV-I ladoo was 0.45 mg which was higher than 0.41 mg although no significant difference was observed between the two. Vitamin C content in TLV-I ladoo is 1.8 mg, significantly higher than the TLC ladoo with a Vitamin C content of 1.3 mg. Riboflavin content in TLV-I ladoo was 0.21mg, significantly higher than 0.12 mg in TLC ladoo. There is no significant difference in the niacin content of 2.9 mg in TLV-I ladoo with 2.7 mg in TLC ladoo. The pyridoxine content in TLV-I ladoo is 0.5 mg which is significantly higher than TLC ladoo. Vitamin B_{12} content in TLV-I ladoo is 0.18 μg, significantly higher than 0.01 μg in TLC ladoo. The folate content of TLV-I ladoo is 52 μg and TLC ladoo is 45 μg, with no significant difference.

Anti-nutrient Content in *Moringa olifera* Leaves

The anti-nutrient content of *Moringa olifera* leaves powder (MOLP) and Fresh *Moringa olifera* leaves (FMOL) is depicted in Table 7.

The analysis of anti-nutrient content in Fresh Moringa oleifera Leaves (FMOL) and Moringa oleifera Leaves

TABLE 7

Anti-nutrient content in MOLP and FMOL

Parameters	MOLP	FMOL
Oxalate (mg/g)	3.4 ± 0.10 [a]	0.93 ± 0.03 [b]
Phytate (mg/g)	0.12 ± 0.01 [a]	0.03 ± 0.01 [b]
Tannin (mg/g)	0.78 ± 0.01 [a]	0.25 ± 0.02 [b]
Lectin (mg/g)	0.23 ± 0.02 [a]	0.08 ± 0.02 [b]
Trypsin inhibitor (mg/g)	89 ± 1.73 [a]	26 ± 1.0 [b]

Values are the means of triplicate measurements ± standard deviation. Values in rows with different letter are significantly different ($p < 0.05$)

TABLE 8

Anti-nutrient present in TLC and TLV-I ladoo

Parameters	TLC	TLV-I
Oxalate (mg/g)	0.9 ± 0.02 [a]	0.81 ± 0.01 [b]
Phytate (mg/g)	3.5 ± 0.05 [a]	2.7 ± 0.17 [b]
Tannin (mg/g)	0.4 ± 0.02 [a]	0.76 ± 0.02 [b]
Lectin (mg/g)	0.15 ± 0.01 [a]	0.12 ± 0.01 [b]
Trypsin inhibitor (mg/g)	18 ± 1.73 [a]	23 ± 1.0 [b]

Values are the means of triplicate measurements ± standard deviation. Values in rows with different letter are significantly different ($p < 0.05$)

Powder (MOLP) reveals variations in key parameters. MOLP exhibited higher levels of oxalate (3.4 mg/g), phytate (0.12 mg/g), tannin (0.78 mg/g), lectin (0.23 mg/g) and trypsin inhibitor (89 mg/g) compared to FMOL, where these values were 0.93 mg/g, 0.03 mg/g, 0.25 mg/g, 0.08 mg/g and 26 mg/g, respectively. The increase in anti-nutrient levels in MOLP is due to the concentration of anti-nutrient during the powdering process. This also implies that the anti-nutrients levels increase during the dehydration process with the increase in nutrients.

Anti Nutrient Content in Til Ladoo

The anti-nutrient content of TLV-I and TLC ladoo is shown in Table 8.

Oxalate content of TLV-I ladoo is 0.81 mg/g, which is significantly lesser than that of 0.9 mg/g in TLC ladoo. The phytate content of TLV-I ladoo is 2.7 mg/g, which is also significantly lower than that of 3.5 mg/g in TLC ladoo. The tannin in TLV-I ladoo is 0.76 mg/g, which is significantly higher than that of 0.4 mg/g in TLC ladoo and this may be accredited to

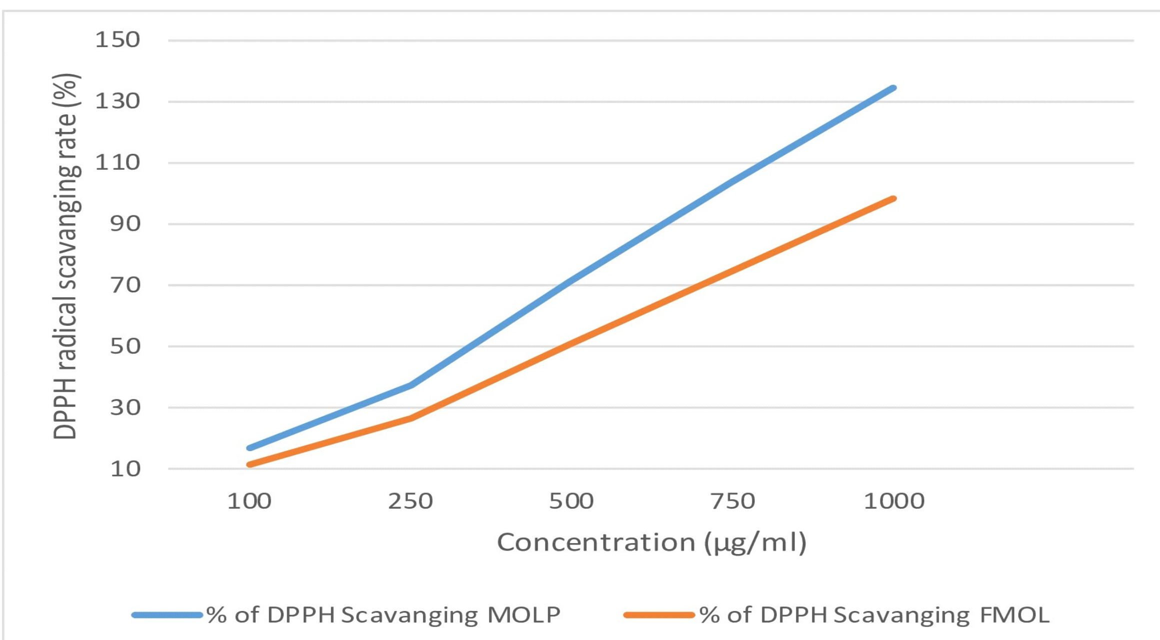

Fig. 1 : DPPH Scavenging activity of Fresh *Moringa olifera* leaves (FMOL) and *Moringa olifera* leaves powder (MOLP)

the higher tannin content in MOLP. The higher amount of oxalic and phytic acids in TLC and lower in tannin is because oxalic and phytic acid are the main antinutrients in sesame seeds, while tannin is present in small amounts (Farran *et al.,* 2000). The lectin in TLV-I ladoo is 0.12 mg/g, significantly lower than 0.15 mg/g in TLC ladoo. The trypsin inhibitor in TLV-I ladoo is 23 mg/g, significantly higher than 18 mg/g in TLC.

Antioxidant Activity (DPPH) of *Moringa olifera* Leaves

The dose-dependent DPPH radical scavenging activities of *Moringa olifera* leaves powder (MOLP) and Fresh *Moringa olifera* leaves (FMOL) are shown in Fig. 1.

Moringa olifera leaves are known to have a high antioxidant potential (Kashyap *et al.,* 2022). Fig. 1 illustrates the DPPH scavenging activity of Fresh Moringa oleifera leaves (MOFL) and Moringa oleifera Leaves Powder (MOLP). The IC_{50} value of MOLP is 345 and FMOL is 494. The graph depicts the antioxidant capacity of both samples as measured by their ability to scavenge DPPH radicals. MOLP exhibited a significantly higher scavenging activity than MOFL, suggesting an augmentation of antioxidant potential during the powdering process. This enhancement aligns with the concentration of bioactive compounds observed in the nutritional analysis. The results underscore the potential health benefits of MOLP, positioning it as a valuable source of antioxidants with implications for addressing oxidative stress-related conditions and promoting overall well-being.

Antioxidant Activity (DPPH) of Til Ladoo

The dose-dependent DPPH radical scavenging activities of TLC and TLV-I are shown in Fig. 2.

The IC_{50} of TLC and TLV-I was 659 µg/ml and 345 µg/ml, respectively, indicating that TLV-I has significantly higher antioxidant activity as compared with TLC ladoo. Moringa leaves, including the dried leaves, have a high antioxidant content with a high free radical scavenging activity (Aly *et al.,* 2022). A similar result was found in MOLP-incorporated products, where incorporating biscuits with moringa leaf powder increases the product's antioxidant content. (Kc *et al.,* 2022).

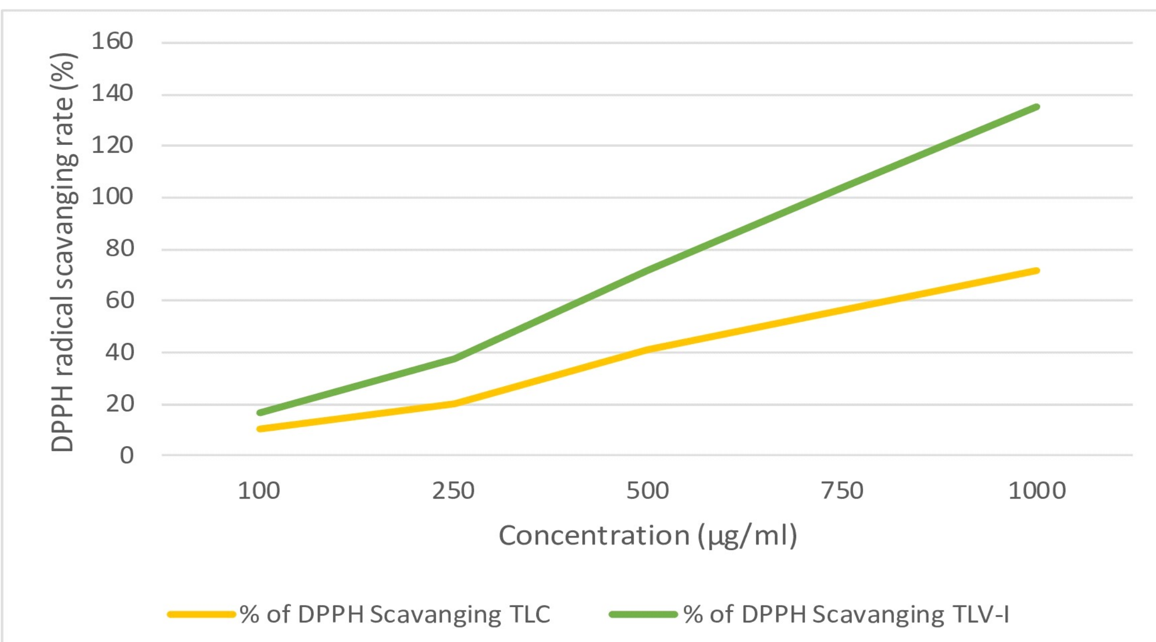

Fig. 2 : DPPH Scavanging activity of TLC and TLV-I

The present investigation demonstrated that the percentage of nutrient, anti-nutrient as well as antioxidant concentration is concentrated when the fresh *Moringa olifera* leaves are converted to *Moringa olifera* leaves powder. It is also seen that the incorporation of MOLP beyond 5 per cent decreases the sensory acceptability of the Til ladoo. While fat and energy decrease significantly, carbohydrates, fat and all the micronutrients increase in quantity with MOLP incorporation. The radical scavenging properties of Til ladoo have also improved with MOLP incorporation. Therefore, the developed product could be considered a novel product with nutritionally improved quality.

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