

# Effect of Dried *Moringa oleifera* Leaves on the Nutritional and Organoleptic Characteristics of Cookies

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## ABSTRACT

In the present study, dried *Moringa oleifera* leaves powder (DMLP) were incorporated at different levels (5, 10 and 15 %) in cookies and their sensory and nutritional properties were evaluated. The results revealed that the contents of protein, dietary fiber, minerals in cookies increased with incorporation of increasing levels of DMLP. Sensory evaluation showed that cookies with acceptable quality and typical *Moringa* leaf flavor could be obtained by incorporating DMLP up to 10 %. Thus, the nutritional quality of cookies could be enhanced by incorporating DMLP in a dose dependent manner.

**Keywords:** *Moringa*- Organoleptic- Cookies

## INTRODUCTION

*Moringa oleifera* is one of the vegetables of the Brassica order and belongs to the family Moringaceae. The Moringaceae is a single genus family with 13 known species (Khawaja, et al., 2010).

*Moringa oleifera* is a small native tree of the sub-Himalayan regions of North West India, which is now indigenous to many regions in Africa, Arabia, South East Asia, the Pacific and Caribbean Islands, and South America. Traditionally, besides being a daily used vegetable among people of these regions, the *Moringa* is also widely known and used for its health benefits. Among commoners, it has earned its name as 'the miracle tree' due to its amazing healing abilities for various ailments and even some chronic diseases. Several investigations were carried out to isolate bioactive compounds from various parts of the plant due to its various applications (Guevara, et al., 1999).

*Moringa oleifera* is a tropical tree possessing numerous economic applications, plus growing in international interest. *Moringa* tree is cultivated and used as a vegetable (leaves, green pods, flowers, roasted seeds), for spice (mainly roots), cooking, and cosmetic oil (seeds) and as a medicinal plant (all plant organs), (Rebecca, et al., 2006).

*Moringa oleifera* is a highly valuable plant, distributed in many tropical and subtropical countries. It has an impressive range of medicinal uses with high nutritional value. Different parts of this plant contain a profile of important minerals, and are a good source for protein, vitamins,  $\beta$  - carotene, amino acids and various

phenolics as well as antioxidants, anti-inflammatory nutrients and omega 3 and 6 fatty acid (Kasolo, et al., 2010).

*Moringa* plant provides a rich and rare combination of zeatin, quercetin, kaempferol and many other phytochemicals. It is also a very important plant for its medicinal value. Various parts of the plant such as leaves, roots, seeds, bark, fruit, flowers and immature pods etc. as cardiac and circulatory stimulants, possess antitumor, antipyretic, antiepileptic, anti-inflammatory, antiulcer, antispasmodic, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, antibacterial and antifungal (Bukar, et al., 2010).

Nutrition content of a plant plays an essential function in medicinal, nutritional, and therapeutic properties (Alkharusi, et al., 2009). It is believed that *Moringa* leaf contains high source of vitamin C, calcium,  $\beta$ - carotene, potassium as well as protein. It works as an effective source of natural antioxidants. Due to the presence of several sorts of antioxidants such as flavonoids, ascorbic acid, carotenoids, and phenolics, *Moringa* is able to extend the period of safety in the food containing fats (Dillard and German, 2000; Siddhuraju and Becker, 2003).

The leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly promising as a food source in the tropics because the tree is in full leaf at the end of the dry season when other foods are typically scarce 'ounce-for-ounce, *Moringa* leaves contain more vitamin A than carrots, more calcium than milk, more iron than spinach, more vitamin C than oranges, and more potassium than bananas, as well as the protein quality of *moringa* leaves rivals that of milk and eggs (Fahey, 2005).

Tumer, et al. (2015) suggested that *Moringa* leaves contain a potent mixture of direct and indirect antioxidants that can explain its various health-promoting effects.

Nandave, et al. (2009) concluded that *Moringa oleifera* extract possesses significant cardioprotective effect, which may be attributed to its antioxidant, antiperoxidative, and myocardial preservative properties.

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Received October 8, 2015, Accepted November 18, 2015

Cookies are widely accepted and consumed in many countries and therefore offer a valuable supplementation vehicle for nutritional improvement. Cookies have been suggested as a good way to use composite flours as they are ready-to-eat, provide a good source of energy, and are consumed widely throughout the world (Arshad, et al., 2007). The term cookies, or biscuits as they are called in many parts of the world, refers to a baked product generally containing the three major ingredients flour, sugar, and fat. These are mixed together with other minor ingredients to form the dough (Mamat, et al., 2010). In the USA, the cookie and cracker manufacturing industry includes about 300 companies with combined annual revenue of about \$11 billion (Hodgen, 2004).

Several studies have been reported on utilization of green leafy vegetables in bakery products, such as dried *Moringa oleifera* and *Tinospora cordifolia* leaves in cookies (Dachana et al. 2010, Sharma et al. 2013), combination of normal / dehydrated *M. koenigii* and *Coriandrum sativum* in buns (Sudha, et al. 2013); *M. koenigii* to extend the shelf life of biscuits produced from blends of sorghum flour and wheat flour (Emmanuel, et al. 2012), curry leaf powder in chapatti, seasoned potatoes and cooked rice as a part of spice mixture (Shanthala and Prakash 2005), mint leaves in biscuits as a source of natural antioxidant (Shivani et al.2006), dried *Amaranthus* leaves in biscuit, cake, pakora, vada, namkpara and kurmura (Singh and Kawatra 2006) and cauliflower leaves in biscuits and shakarpara (Jood et al. 2001). All these studies were aimed to improve the nutritional qualities of the products. The aim of this study was to partially replace wheat flour with 5, 10 and 15 % dried curry leaf powder and to measure organoleptic and nutritional characteristics resulting in cookies.

#### MATERIALS AND METHODS

*Moringa* leaves were washed with water to remove extraneous material. The leaves were dried at 50°C overnight. The dried leaves were coarsely powdered in a blender, sieved through 250 µm sieve and stored in polythene bag.

##### Preparation of blends

Blends were prepared using mixture of wheat flour and *Moringa oleifera* leaves in the ratios of 100/0, 95/5, 95/10 and 85/15w/w. The choice of these levels was made on the initial acceptability trials of the baked product.

##### Cookie preparation

The weight of flour used was adjusted to 14 g/100 g moisture content. The amount of added water was calculated based on the moisture content in the blend.

All ingredients used in the cookies' formulation were commercially available (Table 1). Cookies were prepared by using the AACC method (AACC, 2000) with slight modifications.

**Table 1. Cookie baking formulation**

Ingredient	Quantity
All-purpose Flour, sifted	3 cups
Butter	1cup
Baking soda	2 teaspoon
Eggs	3
Salt	1/2 teaspoon
Cinnamon	1 and 1/2 tablespoon
Sugar	1and 1/2 cup
Chopped walnuts	1cup
Chopped raisins	1cup

**Chemical Composition:** *Moringa oleifera* leaves and prepared cookies were chemically analyzed for moisture, crude protein, fat, crude fiber and ash according to methods described in (AOAC, 2006). Total carbohydrates were calculated by difference. The energy value was calculated using the Atwater factors of 4, 9, and 4 for protein, fat and carbohydrate, respectively (Chaney, 2006). Total soluble fiber was determined by following the enzymatic method (Furda, 1981).

**Total Minerals:** Samples were wet acid-digested, using a nitric acid and perchloric acid mixture (HNO<sub>3</sub>:HClO<sub>4</sub>, 5:1 w/v). The total amounts of Ca, Mg, Fe, Cu, Mn, Zn and Cr in the digested samples were determined by atomic absorption spectrophotometry (Thermo-Elmental, Model 300VA, UK, 1969).

**Sensory characteristics:** The organoleptic characteristics of cookies were determined, using a taste panel, consisting of 10 judges. The panelists were asked to evaluate the products for appearance, color, texture, flavor and overall acceptability. The ratings were on a 9-point hedonic scale, ranging from 9 (like extremely) to 1 (dislike extremely), for each organoleptic characteristic (Austin and Ram, 1971). Results were subjected to analysis of variance.

**Statistical Analysis:** Data were presented as means ± standard deviation (SD). Values were statistically analyzed by one-way analysis of variance (ANOVA test) according to Sendecor and Cochran (1967) using SPSS 22 software package. Differences were considered significant at P values 0.05 using Duncan Multiple Range test.

#### RESULTS

Data presented in Table (2) showed the chemical composition of *Moringa* Leaves. From the obtained data, it could be noticed that *Moringa* Leaves contained (on dry weight basis) 25.8% crude protein, 5.46% fat, 18.42% ash, 11.24% crude fiber, 39.10 carbohydrate and 308.64 Kcal energy.

**Table 2. Chemical composition of Moringa Leaves (on dry weight basis)**

Components	%
Organic mater	81.57±0.38
Ash	18.42±0.38
Crude Fiber	11.24±0.68
Fat	5.46±0.19
Crude Protein	25.80±0.29
Carbohydrate	39.10±0.19
Total metabolizable energy (Kcal/100gm)	308.64±0.23
Minerals (mg/100gm)	
Ca	1100.42±0.29
Mg	220.97±5.18
Fe	89.52±0.69
Cu	7.02±0.15
Mn	9.62±0.19
Zn	7.46±0.06
Cr	1.45±0.02

Data presented in Table(2) illustrate the minerals content of Moringa. Leaves It is obvious that Moringa Leaves contained 1100.42, 220.97, 89.52, 7.02, 9.62, 7.46 and 1.45 mg/100gm Ca, Mg, Fe, Cu, Mn, Zn and Cr respectively.

These results are in agreement with these reported by Busani et al., (2011) who found that the dried leaves of Moringa had crude protein levels of 30.0% and 19 amino acids. The dried leaves had the following mineral contents: calcium(3.65%), phosphorus (0.3%), magnesium (0.5%), potassium (1.5%), sodium (0.164 %), sulphur (0.63%), zinc (13.03 mg/kg), copper (8.25%), manganese (86.8 mg/kg), iron (490 mg/kg) and selenium (363 mg /kg). The values of amino acids, minerals and vitamins profiles reflect desirable nutritional balance.

Charles et al., (2011), stated that the percentages (%) of proteins, moisture, fat, carbohydrates of fresh, and dried leaves were 11.9, 73.9, 1.1, and 10.6 and 27.2, 5.9, 17.1 and 38.6%, respectively. Also, Charles et al., (2011) noticed that the minerals contents for the (Ca, Mg, K, Fe, Zn and P) were 847.1, 151.3, 549.6, 17.5, 1.3 and 111.5 and 2098.1, 406.0, 1922.0, 28.3, 5.4 and 351.1 mg/ 100 g (dry weight basis) in the fresh and dried Moringa oleifera leaves, respectively.

El- Massry, et al. (2013) demonstrated that dried leaves of Moringa contained high amounts of protein and crude fibers which were 26.79 and 18.67 %, respectively, the total carbohydrates contents were higher in fresh and dried leaves of Moringa oleifera, which were 37.85 and 35.90%, respectively. In addition the ash content was 3.64 and 7.92 %, respectively. the analysis of minerals showed that the Moringa leaves were good sources for iron (Fe) than that found in other parts of Moringa oleifera, which values were, 15.98 and

27.76 mg / 100 g (DWB) for fresh and dried leaves, respectively. Essential amino acids such as, methionine, valine, phenylalanine, leucine, lysine and tryptophan, which were 2.12, 6.47, 6.38, 10.12, 6.73 and 2.17 g / 16 g N, respectively, It could be also observed that the Moringa oleifera is reported to have high quality protein which could be easily digested and that is influenced by the quality of its amino acids.

Conclusively, it could be observed that the seeds and leaves of Moringa oleifera are good sources for ether extract, crude protein, ash, and crude fiber as other legumes.

The sensory characteristics of Dried Moringa Leaves Powder (DMLP) substituted cookies are summarized in Table (3). The sensory scores for color, taste, odor, texture

appearance and overall acceptability decreased with increasing levels of DMLP. The color of cookies changed from creamish white to greenish white. The taste was adversely affected at 15 % level as the cookies had very big islands. The texture was very hard and the cookies showed gritty mouth feel and dominating DMLP taste. Replacement of flour with 10% and 15% dried Moringa leaves flour decreased the overall acceptability of cookies. The overall acceptability score for the control was 8.46 on a 9-point hedonic scale which decreased significantly from 7.98 to 7.00 respectively. Cookies made from blends containing 5% level of dried Moringa flours did not differ significantly ( $P < 0:05$ ) from the control.

Sensory evaluation showed that cookies with acceptable quality and typical curry leaf flavor could be obtained by incorporating *Murraya koenigii* leaves up to 10 % (Drisy, et al., 2015).

**Table 3. The sensory characteristics of Dried Moringa Leaves Powder (DMLP) substituted cookies**

	Organoleptic properties					Overall acceptability
	Color	Taste	Odor	Texture	Appearance	
Control	8.50±1.22 <sup>a</sup>	8.15 ±1.54 <sup>a</sup>	8.73± 1.24 <sup>a</sup>	8.35± 1.16 <sup>a</sup>	8.55± 1.38 <sup>a</sup>	8.46 ±1.06 <sup>a</sup>
Wheat: DMLP						
95:5	7.75±1.35 <sup>b</sup>	7.90±1.46 <sup>a</sup>	8.10±1.49 <sup>b</sup>	8.00±1.49 <sup>ab</sup>	8.13±1.42 <sup>a</sup>	7.98±1.24 <sup>a</sup>
90:10	6.77±1.67 <sup>c</sup>	7.15±1.29 <sup>b</sup>	7.50±1.28 <sup>c</sup>	7.68±1.11 <sup>b</sup>	7.28±1.36 <sup>b</sup>	7.14±1.11 <sup>b</sup>
85:15	6.73±1.54 <sup>c</sup>	6.82±1.52 <sup>b</sup>	7.42±1.37 <sup>c</sup>	7.50±1.22 <sup>b</sup>	7.23±1.41 <sup>b</sup>	7.00±0.98 <sup>b</sup>

Scores were: 9 = like extremely to 1 = dislike extremely

abc means in the same column with different superscripts are different significantly (P<0.05)

**Table 4. Chemical composition of Cookies supplemented with DMLP**

Content	Organic mater	Ash	Crude fiber	Fat	Crude Protein	Carbohydrate	Total metabolizable energy (Kcal/100gm)
Wheat: DMLP							
100:0	98.27±0.04 <sup>a</sup>	1.73±0.04 <sup>b</sup>	1.16±0.07 <sup>b</sup>	21.44±0.18 <sup>c</sup>	8.91±0.01 <sup>b</sup>	66.76±0.23 <sup>a</sup>	495.64±0.81
95:5	98.24±0.03 <sup>a</sup>	1.77±0.04 <sup>b</sup>	2.63±0.95 <sup>ab</sup>	22.69±0.04 <sup>b</sup>	9.73±0.33 <sup>ab</sup>	63.19±1.36 <sup>b</sup>	495.89±3.75
90:10	97.45±0.0 <sup>b</sup>	2.55±0.01 <sup>a</sup>	2.70±0.85 <sup>ab</sup>	24.12±0.83 <sup>a</sup>	10.38±0.17 <sup>a</sup>	60.26±0.84 <sup>c</sup>	499.62±7.54
85:15	97.73±0.04 <sup>b</sup>	2.32±0.04 <sup>a</sup>	3.11±0.57 <sup>a</sup>	23.63±0.36 <sup>ab</sup>	9.77±0.60 <sup>ab</sup>	61.21±0.84 <sup>c</sup>	496.23±3.63

abc means in the same column with different superscripts are different significantly (P<0.05)

**Table 5. Minerals composition of Cookies supplemented with DMLP**

Wheat: DMLP	Ca	Mg	Fe	CU	Mn	Zn	Cr
100:0	67.58±2.55 <sup>c</sup>	89.95±0.60 <sup>d</sup>	4.06±0.09 <sup>d</sup>	6.17±0.23 <sup>a</sup>	1.29±0.02	4.09±0.06 <sup>a</sup>	1.24±0.01 <sup>c</sup>
95:5	56.35±0.15 <sup>d</sup>	98.87±0.35 <sup>c</sup>	18.77±0.02 <sup>b</sup>	5.59±0.06 <sup>b</sup>	1.37±0.04	3.90±0.21 <sup>ab</sup>	2.89±0.06 <sup>a</sup>
90:10	71.26±0.01 <sup>b</sup>	132.52±0.33 <sup>b</sup>	15.99±0.33 <sup>c</sup>	5.54±0.13 <sup>b</sup>	1.17±0.04	2.48±0.05 <sup>c</sup>	2.72±0.04 <sup>b</sup>
85:15	103.08±0.06 <sup>a</sup>	138.61±0.21 <sup>a</sup>	31.88±0.53 <sup>a</sup>	4.66±0.02 <sup>c</sup>	1.26±0.03	3.72±0.04 <sup>b</sup>	2.31±0.00 <sup>c</sup>

abcd means in the same column with different superscripts are different significantly (P<0.05)

#### Nutritional characteristics of cookies

The total ash content increased with increase in DMLP indicating increase in the mineral contents in the cookies. The fat content of control and cookies with different levels of DMLP ranged between 21.44 to 24.12 %. The protein content increased from 8.91 to 9.73, 10.38 and 9.77% with addition of 5, 10 and 15 % DMLP respectively (Table 4). Improvement in the nutritional characteristics, such as minerals, dietary fiber, protein, antioxidant activity and shelf life with the use of green leafy vegetables in buns, cookies, biscuits have also been reported (Dachana et al. 2010, Sudha et al. 2013; Sharma et al. 2013; Emmanuel et al. 2012; Shivani et al. 2006). The dietary fiber for control cookies was 1.16 %, 5 % DMLP cookies (2.63 %), 10 % DMLP cookies (2.70 %) and 15 % DMLP cookies (3.11 %).

There was significant enhancement (p<0.05) in iron content of cookies with incorporation of DMLP. The

calcium content of control cookies was 67.58 mg % and showed significant increase (p<0.05) on blending with DMLP. This may be attributed to the higher calcium content of DMLP. Addition of DMLP with 5, 10 and 15% increased the Mg content in a dose dependent manner as a compared with control. Iron content increased significantly (p<0.05) from 4.06 mg/100gm for cookies in control group to 8.77, 15.99 and 31.88 mg//100gm for cookies supplemented with 5, 10, 15% Dried Moringa Leaves Powder (DMLP). Hence, the cookies supplemented with DMLP were found to possess higher nutritive profile than the control with only slight increase in fat content but other nutrients and beneficial components (protein, calcium, iron and dietary fibers) increased significantly in the DMLP incorporated cookies in a dose dependent manner (Table 5).

Baked snack foods such as bread and cookies are widely consumed in every part of the world and have become an attractive target for feeding and nutrition

improvement programs among low-income groups and disaster relief agencies (Claughton and Pearce 1989).

Ogunsina, et al. (2011) demonstrated that replacement of wheat flour with 10%, 20% and 30% debittered moringa seed (DBMS) grits was found to affect cookies quality. Cookies with 20% DBMS grits had the nutty taste of moringa seeds and were acceptable. Cookies with 20% DBMS grits had more protein, iron and calcium.

Through all data concerning different compounds existing in *Moringa oleifera*, it could be clearly concluded that *Moringa* is very rich in many important nutrients to human health such as proteins, fiber, calcium, iron and zinc. It has been proved that it could be practical to utilize different parts of *Moringa* in producing very important and palatable economic products such as moringa tea, moringa juice and cooked seeds. It is also recommended to expand the area cultivated with moringa in the future.

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