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Evaluate the Nutritional Composition of *Moringa oleifera* Leaves Powder in Siwa Oasis and its Effect on Processed Moringa Food Products Properties

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ABSTRACT

The study was undertaken to assess the nutritional value of moringa leaves planted in Siwa Oasis, and the effect of sun and shadow drying methods as well as a sample contains a mix from sun and shadow. Also, seeking for the effect of adding 5, 10 and 15% dried moringa leaves powder, as food ingredient, on olive fruit paste and garlic sauce quality. The results showed that the dried moringa leaves powder had crude protein levels of (22.587%, 24.68% and 31.738%), total carbohydrates (31.263%, 30.146% and 32.079%), ash contents (6.462%, 6.757% and 6.68%) and essential oil (0.14%, 0.12% and 0.17%) for shadow, sun and mixed dried moringa leaves powders, respectively. Regarding the olive fruit paste and garlic sauce, our findings displayed that, samples contain dried moringa leaves powder possess an excellent DPPH radical scavenging as the dried moringa leaves powder percentage increase. Sensory scores showed the highest acceptability with both olive moringa paste and garlic moringa sauce samples with 5% dried moringa leaves powder. So, it could be utilizing dried moringa leaves powder for its nutritional benefits and its potential antioxidant activity in food processing as a natural antioxidant agent.

Key words: Drying methods, Garlic sauce, Moringa leaves, olive-fruit paste, Total phenol, Sensory properties.

Introduction

An increasing in the population growth rate compared to agricultural low production considered to be a reason for searching for a new alternative sources of food in developing countries. *Moringa oleifera* is one of the most widely cultivated 14 species of moringa belong to the family Moringaceae (Rajangam *et al.*, 2001). It is a fast growing plant where it was being found to grow to 6 – 7 m in one year (Odee, 1998). Moringa is common all over the tropics, it called the "Miracle Tree" due to the numerous substances that had such as vitamins, enzymes, amino acids, fats, minerals. So, it is considered to be a good source of nutrients for human consumption (Mensah *et al.*, 2012) especially those people of less developed country which cannot find meat sufficiently every day (Mbailao *et al.,* 2014).

Moringa leaves is alternate, twice or thrice pinnate, grow mostly at the branch tips. They are 20-70 cm long, grayish-downy when young, (Morton, 1991). The leaves are edible and are commonly cooked and eaten like spinach or dried into powder and used in making soups, salads or added as ingredient for baking bread. They are an exceptionally good source of pro vitamin A, vitamins B, and C, minerals (in particular iron), and the sulphur-containing amino acids methionine and cysteine (Foidl *et al*., 2001).

Moringa is one of world's most nutritional crops, once for once, the leaves of Moringa have better carotene than carrots, more vitamin C than oranges, more protein than peas, three times iron than spinach and four times the calcium found in milk (Khan *et al*., 2006; Iqbal and Bhanger 2006; Palade and Chang 2003). So, it could be used as a food supplement around the world because of its many valuable properties (which make it a great scientific interest) where leaves, flowers and immature pods are edible and they could be eaten directly or used in traditional diets in many countries (Anwar and Rashid, 2007). There are variations among the nutritional composition of

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moringa leaves, which depend on species, agro-climatic conditions and cultivation methods (Foidl *et al*., 2001).

People lives in desert regions mixed the dried plant leaves from different drying methods and utilize it without putting the nutrional quality in there concerned, on the other hand, the use of these leaves as an ingredient in food processing to develop food with functional properties, especially in nations where the number of people living under the poverty line is high, has increased recently. Also, identification of inexpensive, easily available food items with rich source of nutrients considered be a big task (Sahay *et al.,* 2017). So, the aim of this research is to evaluate the nutritional composition of the dried moringa leaves powder cultivated in Siwa Oasis, Egypt, with different drying methods which has to our knowledge not previously been evaluated yet. Also, the effect of using dried moringa leaves on the quality characteristics of some food products.

Materials and Methods

Materials:

Fresh moringa leaves cultivated in Khmisa Farm - Siwa station - Desert Research Center – Egypt, were collected in August, 2016. Pickled green olive, garlic, potato, lemon, salt and olive oil used in the manufacture of green olive spread paste and garlic sauce were purchased from local market in Siwa Oasis.

Drying methods of moringa leaves:

The fresh moringa leaves were dried by using two drying methods, shadow drying and sun drying untile final drying (4-6% moisture content). The dried moringa leaves were then grinded to the powder form using a home miller, then rubbing them over a sieve to obtain fine powder. A three groups of dried moringa leaves powder were formed as follows:

- Group (1): Shadow dried moringa leaves powder (ShMLP).
- Group (2): Sun dried moringa leaves powder (SMLP).
- Group (3): Mixed dried moringa leaves powder (MMLP) which is a mix of both shadow and sun dried moringa leaves powder with ratio 1:1.

All samples were then stored in polyethylene bags at 4 ^{o}C until analysis.

Green olive-fruit paste and garlic sauce processing:

Green olive-fruit paste was processed according to Escudero-Gilete *et al.,* (2009)**.** The olives were placed directly in brine (10% NaCl) for 4 months at room temperature. At the end of this fermentation, the pickled olives were de-stoned then minced in a paste machine or blender to reach the correct texture, virgin olive oil (50 g of virgin olive oil/kg of olive fruits) was added during the blending. Garlic sauce (Toumya) was prepared according to (Wikipedia, 2017) using garlic as a primary ingredient with vegetable oil, salt, lemon juice and starch, the garlic is typically finely diced and then the ingredients were added to form the final sauce. The obtained paste and sauce were put into small cleaned glass jars. A thermal sample was performed in order to sterilize the containers (121°C, 30 min.), then kept in a refrigerator at 4°C until analysis. A three samples of both green olive-fruit moringa paste (OMP) and garlic-moringa sauce (GMS) were processed by adding 5,10 and 15 % of dried moringa leaves powder. A control sample of both green olive-fruit paste and garlic-moringa sauce were processed without adding dried moringa leaves powder.

Analytical methods:

The dried moringa leaves powder **(**DMLP) samples were assessed for moisture, crude protein, ether extract, crude fibers and total ash according to the methods described in the A.O.A.C. (2000). The carbohydrate contents were calculated by difference. Total phenol contents of DMLP were determined according to Singleton and Rossi (1965). Consistency of green olive spread paste and garlic sauce samples were measured using viscometer, V60002, FFUNGILAB, Spain (Spindle R7)

100 rpm, torque was maintained at 100%. Moringa essential oil was extracted by using conventional hydro-distillation by Clevenger apparatus (Council of Europe, 1996). Extraction was carried out at 100°C for 180 min. until no more oil was obtained. The essential oil percentage was calculated as (v/w)

Color determination of dried moringa leaves:

Color of dried moringa leaves were measured by using Chroma meter (Konica Minolta, model CR 410, Japan) calibrated with a white plate and light trap supplied by the manufacturer at Cairo University Research Park (CURP), Faculty of Agriculture, Cairo University. Color was expressed using the CIE L, a, and b color system (CIE, 1976). A total of three spectral readings were taken for each sample. Lightness (L*) (dark to light), the redness (a*) values (reddish to greenish) and the yellowness (b*) value (yellowish to bluish) were estimated.

DPPH radical scavenging activity:

The free radical scavenging activity of the extracts against DPPH (1,1-diphenyl-2 picrylhydrazyl) free radical was estimated as described by Brand-Williams *et al.,* (1995). Concentration ranging from 30, 100 and 150 mg/ml were prepared with methanol from each sample. The extract (100µl) and DPPH radical (100 µl, 0.2 mM) dissolved in methanol. The mixture was stirred and left to stand for 15 min. in dark then the absorbance was measured at 517 nm against a control which carried out using 2 mL DPPH solution without the test sample sample. The DPPH free radical scavenging ability was subsequently calculated as follows:

$$\text{DPPH scavenging ability (\%)} = (Ac - At)/Ac \times 100.$$

Where Ac: absorbance of control.
At: absorbance of samples.

Sensory evaluation:

Sensory evaluation of the green olive spread paste and garlic sauce samples were conducted using 10 panelists at Agricultural Industrialization Unit - Desert Research Center – Cairo –Egypt. The samples assessed for color, taste, odor, texture, overall acceptability, using 10-point scale for grading the quality of the samples as described by A.A.C.C. (2000).

Statistical Analysis:

All analyses were performed in triplicate and data reported as mean values. Data were subjected to analysis of variance (ANOVA). All tests were conducted at the 5% significant level.

Results and discussion

Gross chemical analysis of dried moringa leaves powder:

Results obtained in table (1) show that the moisture contents of ShMLP, SMLP and MMLP samples were 5.834%, 4.254% and 4.413%, respectively, with significant differences among samples, this seemed to be appropriate moisture content for further processing and storage. These moisture values were fall below the 15% moisture content required as safe storage limit for plant food materials as reported by Sena *et al.,* (1998). Ash contents of ShMLP, SMLP and MMLP samples were 6.462%, 6.757% and 6.680%, respectively. These values were varied slightly from values obtained by Mbailao *et al.,* (2014) and higher than those reported by Sodamade *et al.*, (2013) the reported value of ash indicated that they are a good source of mineral content.

Moringa is reported to have high quality protein which is easily digested (Foidl *et al.,* 2001). Crude protein content of MMLP sample was significantly higher (31.738%) than the crude protein contents of the other two samples which were 22.587% and 24.680% for ShMLP and SMLP, respectively. The crude protein contents of the MMLP samples were the same with Mbailao *et al.,* (2014) and Moyo *et al.,* (2011) and higher than Ayssiwede *et al*., (2011) who found that the crude protein content was 28.5% for moringa leaves from Senegal. On the other hand, the crude protein content of the SMLP samples was found to be higher than values reported by Joshi and Metha (2010) who mentioned that the value of sun dried moringa leaves from India was 23.32%. This result revealed that the mixing of ShMLP sample with the SMLP sample enhanced the crude protein content, so, it could be considered as an excellent source of protein and it could be used as nutritionally healthy ingredient to improve protein deficiency of human diet.

Ether extract value of DMLP samples were 1.3045%, 2.2059% and 2.2191% for ShMLP, SMLP and MMLP samples, respectively. These values were lower than values obtained by Moyo *et al*., (2011) who found that the ether extract in air dried moringa leaves was 6.5%. However, the crud fat values of SMLP and MMLP samples were in accordance with Oduro *et al.,* (2008) who found the same value (2.23%) for moringa leaves and slightly lower than the crude fat value of moringa leaves 2.3% and 2.43% as reported by Talreja (2011) and Sodamade *et al.* (2013), respectively.

The essential oil of the DMLP produced was a pale yellow oil, the higher percentage was obtained with the MMLP samples (0.17%) followed by ShMLP samples (0.14%) and SMLP sample (0.12%). Marrufo *et al.,* (2013) clarified that moringa leaves contain 0.05% of essential oil on a dry mass basic.

Fiber are important part in a healthy balanced diet. It can help prevent heart disease, diabetes, weight gain and some cancers, and can also improve digestive health. Crude fiber content of the ShMLP, SMLP samples were significantly higher than those of MMLP samples (22.871%) which found to be 32.549% and 31.957% for ShMLP and SMLP samples, respectively. The crude fiber values of ShMLP and SMLP samples were slightly closed to 35.0% obtained by Aja *et al.,* (2013) and higher than 26.32% found by Singh and Prasad (2013).

The maximum significant value of carbohydrates content was observed with the MMLP samples (32.079%) followed by ShMLP (31.263%) and SMLP (30.146%) samples, respectively. Singh and Prasad (2013) found similar amount of carbohydrates (31.93%) for moringa leaves powder, where Yameogo *et al*. (2011) reported that the carbohydrates content ranged from 35.7% to 43.3% for moringa leaves powder. The proportion observed for DMLP samples is adequate enough to meet the required energy for normal development of a body, Also, the values of carbohydrates content in these samples per 100g can provide a lower calorie of energy.

Table 1: Gross chemical composition of dried moringa leaves powder.

Constituents	ShMLP	SMLP	MMLP
Moisture(%)	5.834^{a}	4.254^{c}	4.413^{b}
Ash (%)	6.462^{b}	6.757^{a}	6.680^{a}
Crude fiber (%)	32.549^{a}	31.957^{b}	22.871^{c}
Crude protein (%)	22.587^{c}	24.680^{b}	31.738^{a}
Ether extract (%)	1.305^{b}	2.206^{a}	2.219^{a}
Total carbohydrates (%)	31.263^{b}	30.146^{c}	32.079^{a}
Essential oil (v/w%)	0.14^{b}	0.12^{c}	0.17^{a}

(ShMLP) is the shadow drying moringa leaves powder, (SMLP) is the sun drying moringa leaves powder, (MMLP) is the mixed drying moringa leaves powder. Mean value ± Standard deviation of three replicates, means sharing the same letter in a raw are not significantly different at $p \geq 0.05$.

Total phenol contents of dried moringa leaves powder:

Phenolic compounds can protect the human body from free radicals. They are strong antioxidants capable of removing free radicals, chelate metal catalysts, activate antioxidant enzymes, reduce alpha-tocopherol radicals and inhibit oxidases (Amic *et al.,* 2003).

Figure (1) shows the values of total phenol contents of different DMLP samples. The SMLP sample possess a significant high total phenol content (1028 mg GAE/100g) followed by MMLP (991 mg GAE/100g) and ShMLP (929 mg GAE/100g). So the mixing of both sun and shadow dried moringa leaves enhanced the total phenol contents in the ShMLP sample.

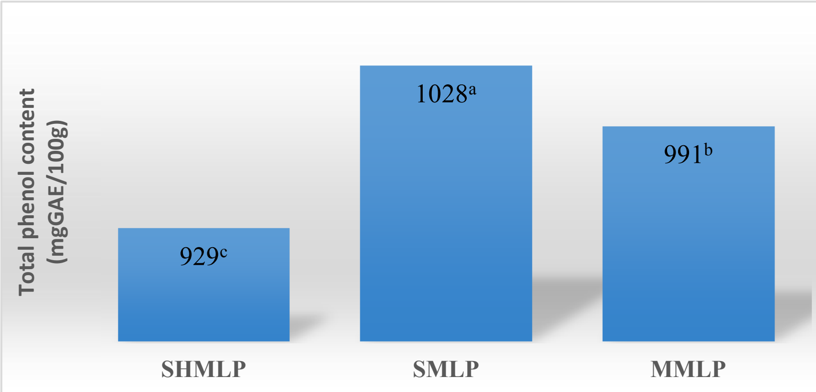

Fig. 1: Total phenol contents in dried moringa leaves powder.

Color of dried moringa leaves powder:

Color of dried food is considered to be a critical quality parameter affected the product acceptance. The mean color values of DMLP are present in Figure (2). For L* and b* values, the SMLP sample was found to have the highest significant values (55.46 and 27.89), followed by MMLP sample with 54.68 and 28.71 for L* and b*, respectively, where the ShMLP sample appeared to have the lowest significant L* and b* values. In case of greenness, high a* value was obtained with the ShMLP sample followed by MMLP sample where the lowest significant value was found with the SMLP sample with significant difference ($p \geq 0.05$). The decrement in both L* and b* values and increment in a* values exhibit more greenness color, so, the mixing of SMLP with ShMLP reinforcement the green color in the SMLP sample. Our results were in accordance with Ali *et al.* (2017) who also illustrated that sunlight had more effect on yellowness of dried moringa leaves. The color variations affected during drying samples may be caused by the destruction of pigments presented in the leaves as reported by Lopez *et al.* (2013).

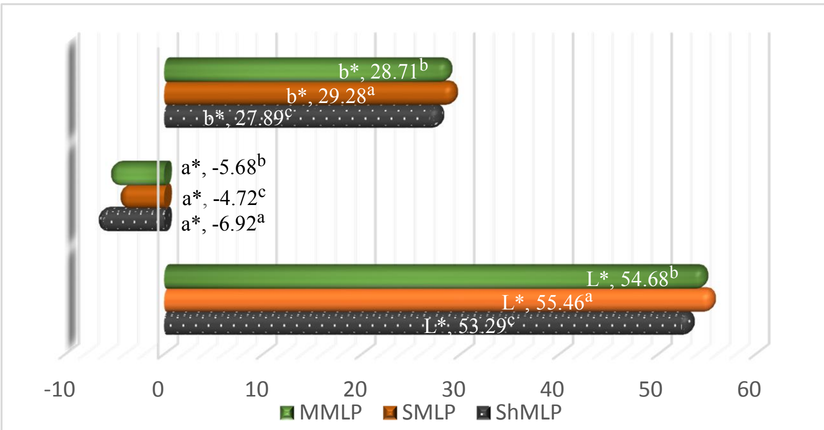

Fig. 2: Color of dried moringa leaves powder

Effect of adding DMLP on Green olive-fruit paste and garlic sauce quality:

Olive-fruit paste is an edible develop olive based products, it was introduced into the global market a few years ago, it can be consumed as such or incorporated into other products (Anniva and Tsimido, 2009). Garlic sauce (middle east garlic sauce) used as a dip sauce (appetizer or condiment) to add flavor to many food and dishes such as steak, chicken, fish and fries (Wikipedia, 2017).

DPPH free radical scavenging of OMP and GMS:

DPPH is a free radical donor that accepts an electron or hydrogen to become a stable diamagnetic molecule (Je *et al.,* 2009). The DPPH radical scavenging ability of the olive moringa paste (OMP) and garlic moringa sauce (GMS) samples as represented in table (2) revealed that there was a significant increment in the values of scavenged DPPH radicals as the concentrations of DMLP increase among all extracts concentration in GMS. With regards to OMP samples, our findings display that the OMP5 sample exhibit a high significant scavenged DPPH radical values in all extracts concentrations as compared with the OMP10 and OMP15, moreover, there were no significant differences noticed in the scavenged DPPH radical values between the OMP15, OMP10 and OPC samples at 100 mg/ml and 150 mg/ml extract concentration ($p \geq 0.05$). These findings indicated that the DMLP is a powerful natural antioxidant activity. Sreelatha and Padma (2009) reported that the scavenging activity of moringa leaf is attributed to its hydrogen donating ability. Also, Akomolafe *et al.* (2012) illustrated that *Moringa oleifera* leaf extracts prevent lipid peroxidation and thus preventing the initiation of lipid peroxidation.

Table 2: DPPH radical scavenging of olive moringa paste and garlic moringa sauce.

Concentration of extract (mg/ml)	Olive moringa paste				Garlic moringa sauce			
	OPC	OMP5	OMP10	OMP15	GSC	GMS5	GMS10	GMS15
30	90.7^{b}	91.2^{a}	90.4^{c}	90.8^{b}	8.7^{d}	43.3^{c}	82.3^{b}	88.1^{a}
100	91.4^{b}	91.9^{a}	91.6^{b}	91.5^{b}	9.5^{d}	76.3^{c}	89.4^{b}	89.9^{a}
150	92.5^{b}	93.1^{a}	92.6^{b}	92.7^{b}	11.2^{d}	82.2^{c}	90.4^{b}	91.9^{a}

(OPC) the control olive paste, (OMP5) the olive paste with 5% DMLP, (OMP10) the olive paste with 10% DMLP, (OMP15) the olive paste with 15% DMLP, (GSC) the control garlic sauce, (GMS5) the garlic sauce with 5% DMLP, (GMS10) the garlic sauce with 10% DMLP, (GMS15) the garlic sauce with 15% DMLP.
Mean value ± Standard deviation of three replicates, means sharing the same letter in a raw are not significantly different at p≥0.05.

Consistency of OMP and GMS:

The consistency measurement of food products is a very important step to take guidelines in formulation, processing and product development (Shahnawaz and Shiekh, 2011). For the olive moringa paste, the higher consistency values were observed with the OMP15 then OMP10 samples, where the consistency of the OMP5 sample was slightly higher than the OPC sample (Fig.3a) However, the garlic moringa sauce samples exhibited a gradual increment trend in consistency values where the higher consistency values appear with sample GMS15 > GMS10 > GMS5 > GSC, respectively (Fig. 3b).

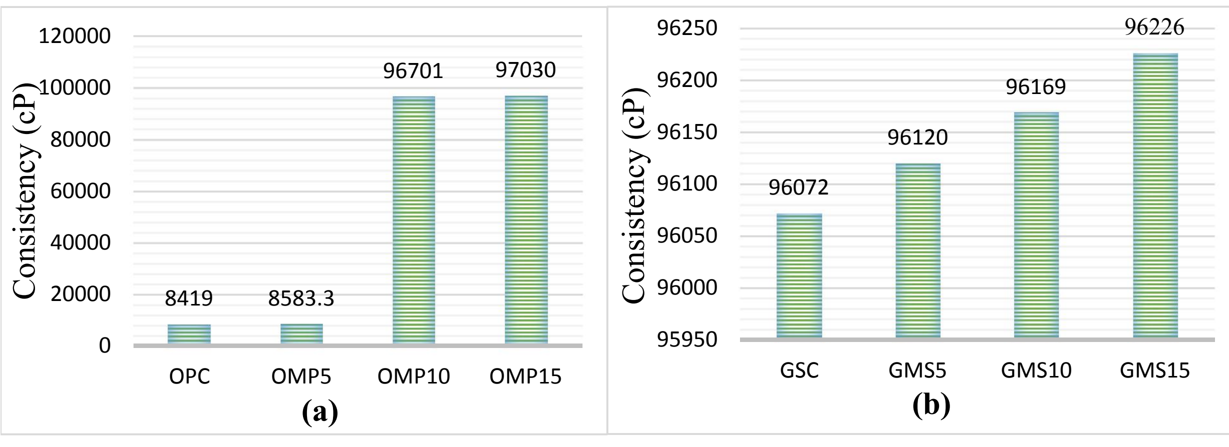

Fig. 3: Consistency of olive moringa paste and garlic moringa sauce.

Sensory evaluation of OMP and GMS:

Data in table (3) demonstrate the sensory properties of both OMP and GMS samples. For OMP samples, there was a high significant difference between OMP5 sample and both OMP10 and OMP15 samples for color, taste and texture attributes, whilst there is no significant difference between OMP5 sample and OPC sample. Also, the same trend was observed with the GMS sample, where the GMS5 sample showed the highest significant score for color, taste and texture in comparison with GMS10 and GMS15 samples.

Table 3. Sensory properties of olive moringa paste and garlic moringa sauce.

Sensory properties	Olive moringa paste				Garlic moringa sauce			
	OPC	OMP5	OMP10	OMP15	GSC	GMS5	GMS10	GMS15
Color	9.3^a	9.4^a	8.7^b	8.6^b	9.2^a	9.2^a	8.3^b	8.2^b
Taste	9.3^a	9.4^a	8.8^b	8.4^c	9.2^b	9.4^a	8.8^c	8.1^d
Odor	8.6^a	8.6^a	8.5^a	8.6^a	9.2^a	9.2^a	9.2^a	9.1^a
Texture	8.9^a	8.9^a	7.9^b	7.7^c	9.4^a	9.5^a	8.1^b	7.9^c
Overall acceptability	8.8^b	9.2^a	7.8^c	7.8^c	9.5^a	9.5^a	8.5^b	7.7^c

(OPC) the control olive paste, (OMP5) the olive paste with 5% DMLP, (OMP10) the olive paste with 10% DMLP, (OMP15) the olive paste with 15% DMLP, (GSC) the control garlic sauce, (GMS5) the garlic sauce with 5% DMLP, (GMS10) the garlic sauce with 10% DMLP, (GMS15) the garlic sauce with 15% DMLP.
Mean value ± Standard deviation of three replicates, means sharing the same letter in a raw are not significantly different at p≥0.05.

There is no significant effect on the odor among the OMP and GMS samples. The highest significant score (p≥0.05) of the overall acceptability for both OMP and GMS were sequentially found with OMP5 and GMS5 samples. Finally, the addition of DMLP with 5% enhanced the sensory properties of both OMP and GMS.

Conclusion

Our findings indicated that, the dried moringa leaves powder are rich in nutrients, where it contains appreciable amount of essential oil. Furthermore, the mixing of shadow and sun dried moringa leaves powder have improved protein, total carbohydrates content and essential oil and so had a potential to be used as a food additive with multiple purposes. Addition of dried moringa leaves powder exhibit a very excellent DPPH radical scavenging activity, thus, it is considered to be a perfect natural antioxidant ingredient that could be used as functional component in food products. According to the sensory evaluation, both OMP5 and GMS5 were preferred due to their color, texture and its delicate as well as smooth taste.

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