Chemical and Technological Studies of *Moringa oliefera* Lam. Leaves and Its Phenolic Extracts

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ABSTRACT

The objective of the present study was to characterize the sun dried and dehydrated *Moringa oleifera* Lam leaves in terms of their gross chemical composition , mineral content, fatty acid composition , phenolic compounds, antioxidant and antimicrobial activities as well as the possibility of using these leaves in preparing some food products. The results indicated that significant differences were found between the sun dried and dehydrated leaf powder with regard to their content of crude ether extract and carbohydrate. Generally, leaf powder may be considered as a good source of the microelements such as Ca, K, Na and Mg. The most predominant saturated and unsaturated fatty acids were palmitic, oleic, linolenic and linoleic acids, respectively. The data revealed a high content of phenolic compounds, ascorbic acid and antioxidant activity being 38.07-42.02 mg/g, 15.10-20.43 mg/100g and 79.92- 83.4 % for sun dried and dehydrated leaf powder, respectively. Gallic, chlorogenic, ellagic and ferulic acids were identified by HPLC in leaf powder. Furthermore, *Moringa oleifera* leaf extract has a noticeable antimicrobial effect on growth of *Bacillus subtilis*, *Escherichia coli*, *Saccharomyces cerevisiae* and *Aspergillus niger*. All products containing either sun dried or dehydrated moringa leaf powder were more acceptable with respect to their organoleptic attributes mainly taste and colour.

Key words: Moringa oleifera Lam. gross chemical compositiom, antioxidant activity, polyphenolic compounds, technological utilization.

INTRODUCTION

Moringa oleifera Lam., a member of the family Moringaceae, is a fast-growing plant widely available in the tropics and subtropics with great economic importance for the food and medical industry (Booth & Wickens, 1988, Becker & Makkar, 1999, Foidl *et al*., 2001). *Moringa oleifera* is one of the 14 species of genus *Moringa*, which are native to India, Africa, Arabia, Southeast Asia, the Pacific and Caribbean islands, and South America (Sengupta & Gupta, 1970).The seeds are rich in oil and protein and can also be used for the purification of water. The roots are considered as a good source of spices. *Moringa oleifera* is commonly known as drumstick tree or horseradish tree. The leaves are highly nutritious, being a significant source of β-carotene, vitamin C, protein, iron and potassium. Leaves can be eaten fresh, cooked, or stored as dried powder for many months without refrigeration, and reportedly without loss of nutritional value (Parrotta, 2001). The species are drought resistant and tolerate a wide range of soil and rainfall conditions. Various varieties of *Moringa oleifera* have been developed to meet the tastes of local populations (Rajan, 1986). Different parts of this plant, i.e., leaves, flowers, roots and fruits, have traditionally been used for dietary purposes as vegetables (Siddhuraju & Becker, 2003). Fresh leaves have been used by Indian inhabitants for the preparation of cow and buffalo ghee from butter fat. Its leaves are a valuable source of provitamin A and vitamin C. They promote digestion, and are used in catarrhal afflictions as well as for treating wounds (Pal *et al*., 1995). Leaves of *Moringa oleifera* have been reported to regulate thyroid status and possess radio protective and antitumor activities. Pod showed hypotensive and chemomodulatory effects whereas, seeds have been reported for coagulative, antimicrobial and antitumor activity (Faizi *et al*., 1988, Murakami *et al*., 1988, Guevara & Vargas, 1999, Rao *et al*., 2001). Roots, leaves, flowers, gum and the aqueous infusion of seeds also have been found to possess diuretic activity (Caceres *et al*., 1992). Roots possessed antimicrobial and anti-inflammatory activity (Ezeamuzle *et al*., 1996.). Extracts from *Moringa oleifera* roots and flowers were found to have a significant hepatoprotective effect (Murakami *et al*., 1998).. *Moringa oleifera*

contains various phytochemicals, viz. carotenoids, vitamins, minerals, amino acids, sterols, glycosides, alkaloids, flavonoids and phenolics (Anwar *et al*., 2007). Aqueous and methanolic extract of *Moringa oleifera* leaves have been reported only to limited extent for their antioxidant properties (Siddhuraju & Becker, 2003). Although some people have used this plant as a food, there is a little information about its chemical and nutritional characteristics (Teixeira *et al*., 2014). The objective of the present study was to characterize the leaves of *M. oleifera* in terms of their gross chemical composition, polyphenol content, antioxidant and antimicrobial effects. Moreover, the study aimed to investigate the possibility of using *Moringa olifera* leaves in preparing some food products.

MATERIALS AND METHODS

Materials:-

Moringa olifera leaves were brought from private farm located at kilo 43 El-Sahrawy road, Borg El Arab city, Alexandria Governorate, Egypt. Leaves were brought fresh, dried as will be mentioned later on and kept in tightly closed glass jars in refrigerator at 4°C until used.

Methods:-

Preparation of sun dried and dehydrated powder of *Moringa oleifera* leaves:

Sun drying and dehydration of moringa leaves were prepared as shown in Fig. (1) as follows:-

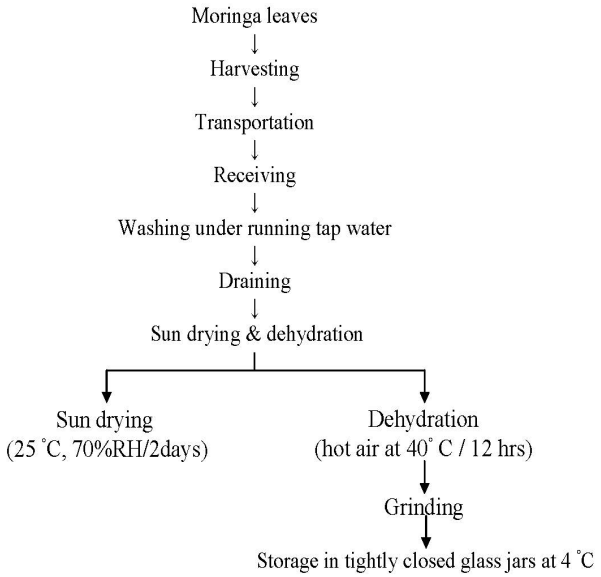


Fig .1: Sun drying and dehydration of *Moringa oleifera* leaves

Analytical methods:

Proximate chemical composition: Moisture, ash, crude protein (N x 6.25) and crude ether extract were determined as described in the AOAC (2003) unless otherwise is stated. Total carbohydrates were calculated by difference.

Minerals: (Fe, , Mg, Ca, Zn, and P) were measured as described in the AOAC (2003) using Perkin Elmer Atomic Absorption Spectrophotometer (Model 2380). On the other hand, Na and K were determined using Flame Photometer (Model PEP7,England).

Ascorbic acid determination: Ascorbic acid was determined according to the AOAC (2003) procedure using 2 , 6 dicholorophenol indophenol dye.

Fatty acid composition: Total lipids were extracted with a mixture of chloroform, methanol (2:1, v/v) as outlined by the procedure of Folch *et al*. (1957) . Fatty acid methyl esters of oil samples were prepared as described by Radwan (1978) in screw cap vial using 1% H_2 SO_4 in methanol under stream of nitrogen gas. The closed vials were heated in an oven at 90 ◦ C for 90 min. Gas chromatographic analysis was carried out using ACME model 6100 GC (Young LTN Instrument Co., Korea) fitted with a split/splitless injector and FID detector. Standard fatty acid methyl esters were used for identification.

Extraction of total phenolic compounds: The powder of dry sample (10 g) was macerated in absolute methanol (100 ml) for 24 hr at room temperature according to Ziada (2002). The extracts were filtered, then evaporated under vacuum using rotary evaporator at 45 ºC and weighed to determine the extract yield of *Moringa oleifera* leaves. These extracts were used for determination and identification of polyphenols.

Determination of total phenolic content: The total phenolic content was determined in the extract following the Folin-Ciocalteu method (Singleton & Rossi, 1965).

Identification of phenolic compounds by HPLC: The method of Shan *et al*. (2005) was used with some modifications in HPLC device as follows:- Phenolic compounds were extracted using 80% methanol containing 2 ml 0.1M sodium fluoride to prevent oxidation of phenolic compounds. Separation of the phenolic compounds was carried out using HPLC system (Perkin Elmer Series 200)

with a UV- visible detector (Perkin Elmer Series 200) at 290 nm, the mobile phase was 5% formic acid in a gradient of methanol containing from 5 to 80% final concentration. Compounds were identified by comparison with known standards (ferulic acid, caffeic acid, vanillic acid, *p*- coumaric acid, gallic acid, rosmarinic acid, thymol and catechin "Sigma- Aldrich Co.")

Antioxidant activity: Antioxidant activity was measured by the N, N Dimethyl –*p*–phenylenediamine dihydrochloride (DMPD) as outlined by Fogliano *et al.(*1999).

Antimicrobial activity: Antimicrobial activity of *Moringa oleifera* leaves extract was determined according to the method of Sahin *et al.* (2004) using disc diffusion assay, where a disc with methanol was used as a control.

Technological methods:

Figure (2) shows the diagrammatic procedures for preparing moringa tea, vegetable soup, *Quarish* cheese and mashed potatoes containing different concentrations (2,4,6 and 8%) of sun dried and dehydrated *Moringa oleifera* leaves powder.

Sensory evaluation of *Moringa oleifera* leaves products: Colour, taste, odour, texture, appearance and overall acceptability of different products containing dried and dehydrated leaf powder of *Moringa oleifera* including moringa tea, vegetable soup, *Quarish* cheese and mashed potatoes were assessed by 15 panalists from Food Science and Technology Departement, Faculty of Agriculture, Alexandria University. The panelists were asked to score the aforementioned attributes according to a standard hedonic rating scale from 9 (like exteremely) to 1 (dislike extremely) according to Karamer & Twigg (1973).

Statistical analysis: Statistical analysis was done by ANOVA according to Steel & Torrie (1980). Factor t-test and L.S.D procedures avail-

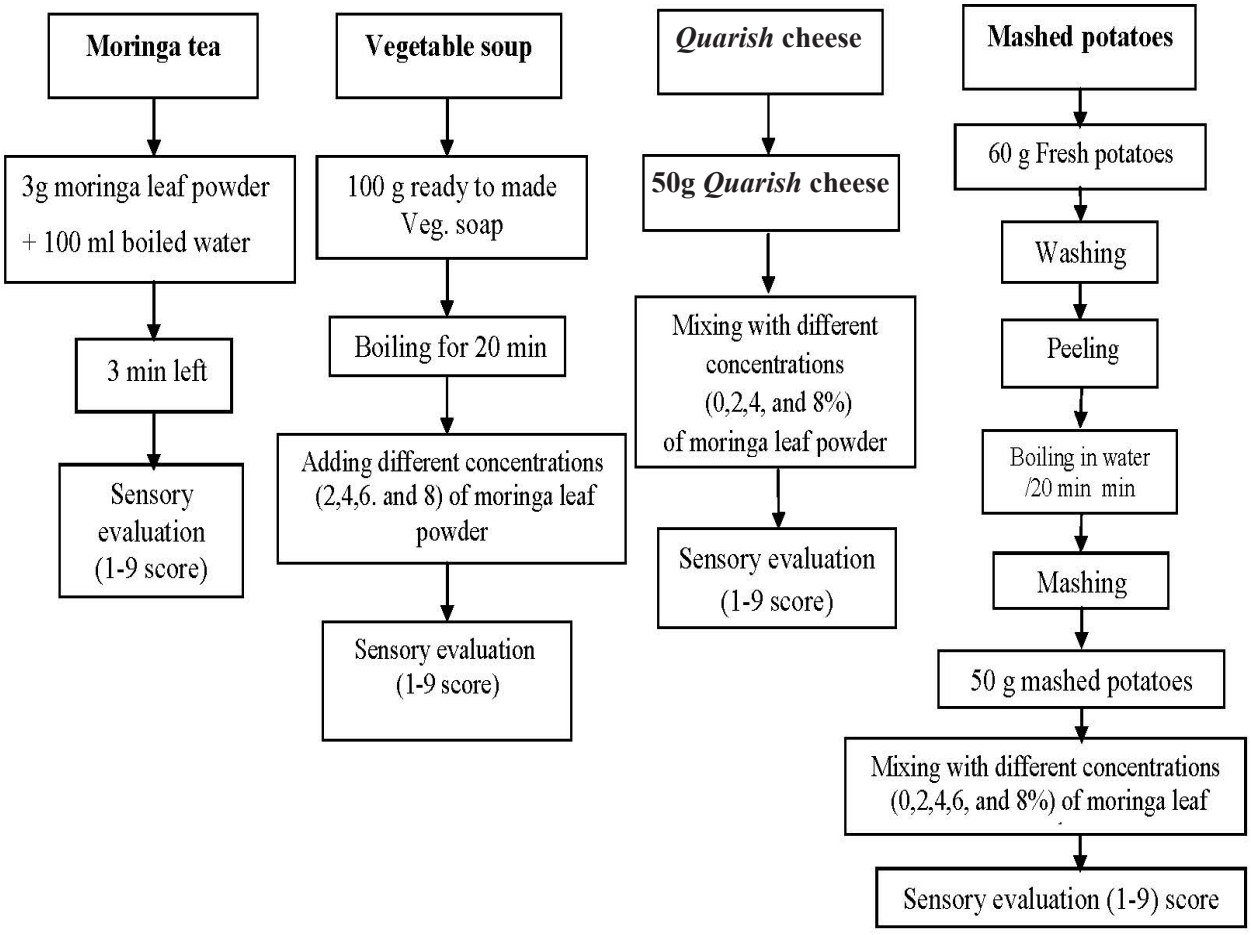


Fig.2: Diagram of procedures for preparing moringa tea, vegetable soup, *Quarish* cheese and mashed potatoes containing different concentrations of *Moringa oleifera* leaves powder

able within the SAS software package (Version 9.13, 2008).

RESULTS AND DISCUSSION

Gross chemical composition of *Moringa oleifera* leaves: The results shown in Table (1) indicate that there were considerable amounts of protein, crude ether extract, ash and carbohydrates in *Moringa oleifera* leaves. In accordance with the results obtained in the present study, Gupta *et al*. (1989) , Makkar & Becker (1996), Khalafalla *et al*. (2010), Teixeira *et al.* (2014) found that, the whole *Moringa oleifera* leaf flour contained 25.0–28.7% crude protein, 5.4-11.5% fat, 8.4-10.9% ash, and about 44.4% carbohydrate. The results in Table (1) also show significant differences between sun dried leaves and the dehydrated ones with regard to their content of crude ether extract and carbohydrates.

Table 1: Chemical composition of *Moringa oleifera* leaves (on dry weight basis):-

Components(%)	Samples	
	Sun dried	Dehydrated
Moisture	$8.91^{a}\pm 0.1$	$6.21^{b}\pm 0.02$
Crude protein (N x 6.25)	$25.68^{a}\pm 0.19$	$25.90^{a}\pm 0.40$
Crude ether extract	$3.44^{b}\pm 0.15$	$4.76^{a}\pm 0.31$
Ash	$10.76^{a}\pm 0.55$	$10.99^{a}\pm 0.27$
*Carbohydrates	$60.12^{a}\pm 0.34$	$58.35^{b}\pm 0.28$

Values are means of triplicates ± S.D.
Means within a row not sharing the same superscript are significantly different at $P \leq 0.05$
* Calculated by difference

Minerals: Mineral contents of *Moringa oleifera* leaves are given in Table (2). The results indicate that Ca, K, Na, Mg and P were the major minerals, In addition, microelements such as Fe and Zn are found in small concentrations. Slight variations in mineral contents were noted between values of both the sun dried and the dehydrated leaves of *Moringa oleifera*. The aforementioned data are more or less in accordance with those reported by Amaglo *et al*. (2010), Nouman *et al*. (2013), Teixeira *et al*. (2014). Generally, *Moringa oleifera* leaves may be considered as a good source of the macro elements such as Ca, K, Na and Mg.

Fatty acid composition: Table (3) shows the fatty acid composition of the total lipids extracted from the leaves of *Moringa oleifera*. In general, the total saturated fatty acids varied between 22.44, and 24.05%. The most abundant saturated fatty acid was palmitic acid. In addition, small amounts of C14:0 and C18:0 were also present. On the other hand, total unsaturated fatty acids varied between 75.95 and 77.56%. The most predominant unsaturated fatty acids were oleic, linolenic and linoleic acids. In accordance with the results obtained here, Amaglo *et al.* (2010) and Machado *et al*. (2010) mentioned that linolenic, palmitic, linoleic and oleic acids were the major fatty acids in the oil extracted from *Moringa oleifera* leaves. The ratio of unsaturated to saturated fatty acids varied from 3.16 to 3.46. This is because the total amount of unsaturated fatty acids was higher than those of saturated ones. This ratio is higher than that of the common edible vegetable oils in which their degree of unsaturation is quite low. As shown from the Table (1), slight fluctuation was

Table 2: Mineral contents of *Moringa oleifera* leaves (mg/100g sample).

Element	Samples	
	Sun dried	Dehydrated
Ca	$2007.60^{a}\pm 7.0$	$2015^{a}.33^{a}\pm 15.0$
K	$1216^{b}.15\pm 6.0$	$1336.6^{a}\pm 16.0$
Na	$652^{a}.62\pm 12.0$	$614^{a}.2\pm 10.0$
Mg	$541.59^{a}\pm 11.0$	$416.91^{b}\pm 16.0$
P	$220.5^{a}\pm 10.0$	$219.6^{a}\pm 19.0$
Fe	$41.33^{a}\pm 5.0$	$35.16^{a}\pm 5.0$
Zn	$6.93^{a}\pm 0.3$	$6.15^{a}\pm 0.2$

Means within a row not sharing the same superscript are significantly different at $P \leq 0.05$

Table 3: Fatty acid composition of *Moringa oleifera* leaves.

Fatty acids	Sun dried	Dehydrated
Myristic $C_{14:0}$	$4.16^{a}\pm 0.16$	$3.74^{a}\pm 0.06$
Palmitic $C_{16:0}$	$16.30^{a}\pm 0.15$	$14.20^{b}\pm 0.2$
Stearic $C_{18:0}$	$3.59^{a}\pm 0.19$	$4.24^{a}\pm 0.12$
Saturated	$24.05^{a}\pm 0.15$	$22.44^{b}\pm 0.2$
Palmitoleic $C_{16:1}$	$3.32^{a}\pm 0.12$	$2.35^{a}\pm 0.10$
Oleic $C_{18:1}$	$40.19^{a}\pm 0.19$	$41.66^{a}\pm 0.26$
Linoleic $C_{18:2}$	$8.33^{a}\pm 0.13$	$7.34^{b}\pm 0.14$
Linolenic $C_{18:3}$	$20.6^{b}\pm 0.60$	$23.83^{a}\pm 0.20$
Lignoceric $C_{20:1}$	$5.51^{a}\pm 0.20$	$2.38^{b}\pm 0.18$
Unsaturated	$75.95^{b}\pm 0.15$	$77.56^{a}\pm 0.20$

Means within a row not sharing the same superscript are significantly different at $P \leq 0.05$

noted between the oil extracted from the sun-dried and the dehydrated leaves of *Moringa oleifera*.

Polyphenols, ascorbic acid and antioxidant activity in *Moringa oleifera* leaves: Total polyphenols, ascorbic acid as well as antioxidant activity of *Moringa oleifera* leaves are shown in Table (4). The data reveal high contents of phenolic compounds, ascorbic acid and antioxidant activity, being 42.02 (mg/g), 20.43 (mg/100g) and 83.4%, respectively in sun dried *Moringa oleifera* leaves. On the other hand, the dehydrated *Moringa oleifera* leaves had slightly lower values of the aforementioned parameters which could be attributed to the temperature used during the dehydration process. These results indicate the capability to use *Moringa oleifera* leaves as natural antioxidants in food processing. In accordance, Siddhuraja & Becker (2003) reported that, the antioxidant activities of methanolic leaf extract of *Moringa oleifera* from three different agro-climatic origins are mainly due to its high content of phenolics and flavonoids. On the other hand, Iqbal & Bhanger (2006) found that the total phenolics of *Moringa oleifera* leaves were 2.79/100g DM, while Moyo *et al*. (2012) found that total polyphenolic contents of the extract of *Moringa oleifera* leaves were 20.33 and 40.27 mg tannic acid/g for acetone and aqueous extracts, respectively and it was also suggested that, the aqueous and acetone extract of *Moringa oleifera* leaves have potent antioxidant activity which may be attributed to the presence of polyphenolic compounds. Further, Nascimento *et al*. (2013) showed that higher amounts of phenolic compounds exist in the leaves of *Moringa oleifera* , justifying a higher antioxidant capacity of these extracts towards the DPPH radicals. Furthermore, Vongask *et al*. (2013) indicated that the highest contents of total phenolics, total flavonoids are the major active compounds and the most potent antioxidant activity are obtained with 70% ethanol.

Table 4: Polyphenols, Ascorbic acid, and Antioxidant activity in *Moringa oleifera* leaves.

Component	Samples	
	Sun dried	Dehydrated
Polyphenols (mg/g)	$42.02^{a}\pm0.62$	$38.07^{b}\pm0.61$
Ascorbic acid (mg/100g)	$20.43^{a}\pm0.42$	$15.10^{b}\pm0.34$
Antioxidant activity (%)	$83.4^{a}\pm0.40$	$79.92^{b}\pm0.87$

Means within a row not sharing the same superscript are significantly different at $P \leq 0.05$

Identification of phenolic compounds by HPLC: Figures (3 & 4) show the phenolic compouds of methanolic extract of sun dried and dehydrated *Moringa oleifera* leaves. Sun dried *Moringa oleifera* leaves extract exhibited eleven separated phenolic compounds. Only, four compounds could be identified as follows: gallic acid, chlorogenic acid, ellagic acid and ferulic acids. On the other hand, dehydrated *Moringa oleifera* leaves ex-

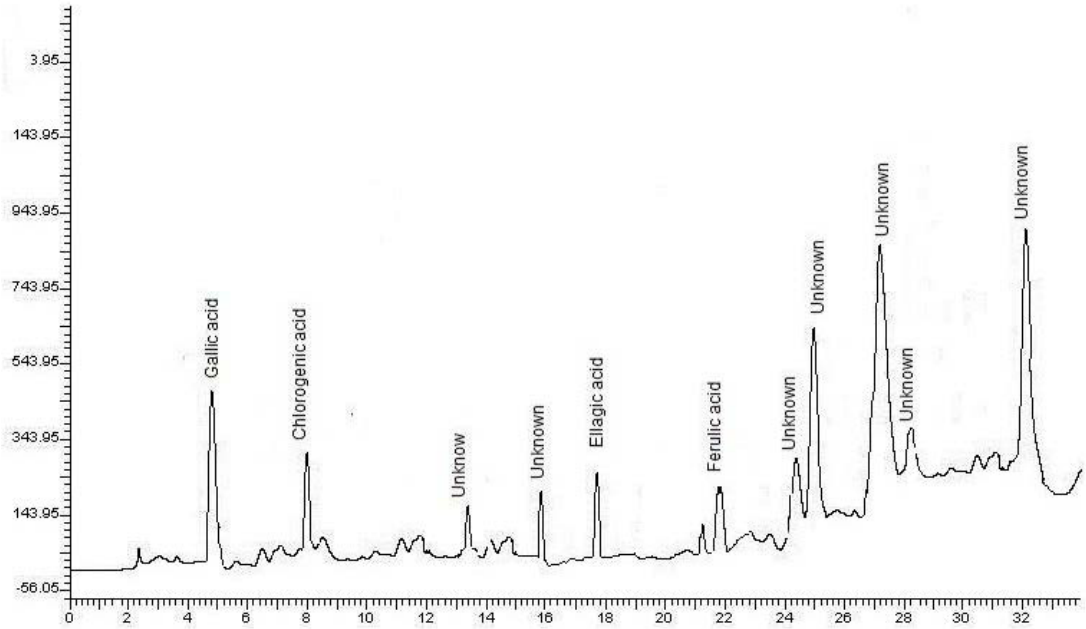


Fig. 3: The HPLC chromatogram for separation of phenolic compounds from sun dried *Moringa oleifera* leaves extract.

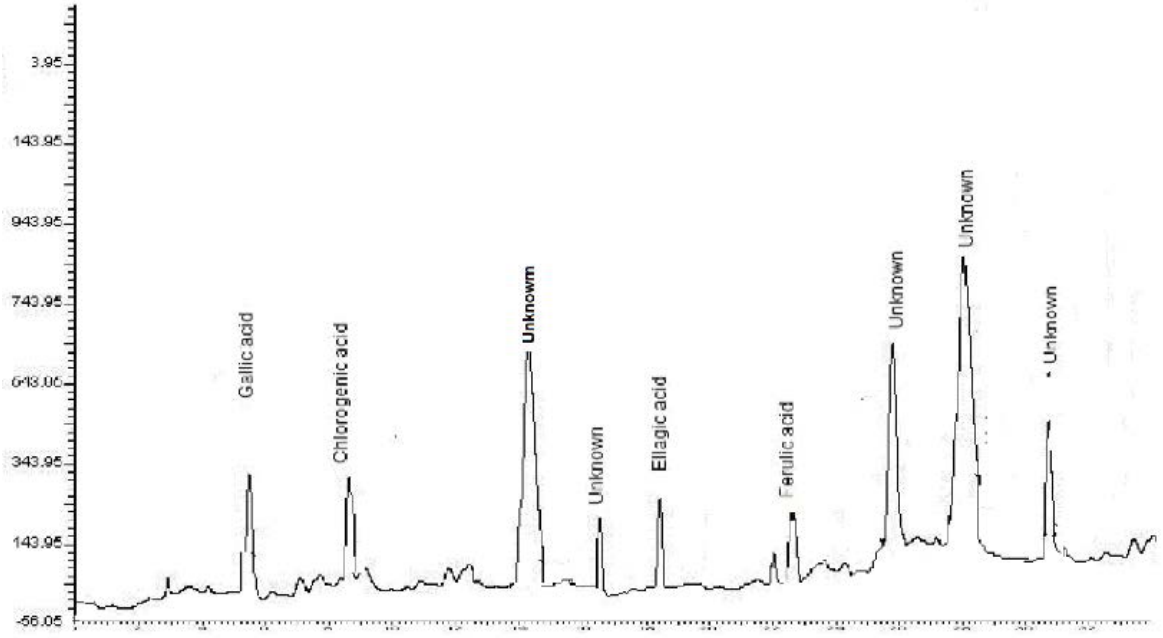


Fig. 4: The HPLC chromatogram for separation of phenolic compounds from dehydrated *Moringa oleifera* leaves extract

tract showed nine separated phenolic compounds. Only four compounds could be identified as those found in the sun dried extract. Coppin *et al*. (2013) analyzed phenolic compounds by HPLC –UV – MS- and identified twelve flavonoids including quercetin and kaempferol glucosides and glucoside malonates as major constituent. Verma *et al*., (2009) reported that (ethyl acetate/polyphenolic fractions) of *Moringa oleifera* leaves was examined for their specific polyphenolic composition by using HPLC and revealed the presence of phenolics-including gallic acid, chlorogenic acid, ellagic acid, ferulic acid, kaempferol , quercetin and rutin. extract by HPLC

Antimicrobial activity of *Moringa oleifera* leaves extract: Data presented in Table (5) show the antimicrobial effect of *Moringa oleifera* leaves extract on growth of two strains of bacteria (*Bacillus sublilis* B505, and *Escherichia coli* DH5X), one strain of yeast (*Saccharomyces cerevisiae*) and one strain of fungi (*Aspergillus niger,* wild type). The results clearly show that, there were clear inhibition zone around the studied extract. The diameter of the inhibition zone was 28.0 and 33.0 mm for *Bacillus-sublilis* , 15.0 and 22.0 mm for *Escherichia coli* , 30.0 and 25.0 mm for *Saccharomyces cerevisiae* and finally 13.0 and 19.0 mm for *Aspergillus niger* for the extract of sun dried and dehydrated *Moringa oleifera* leaves, respectively. The obtained data showed that *Moringa oleifera* leaves extract had a noticeable antimicrobial effect on growth of the investigated strains.Moreover, dehydrated leaves extract was found to be more effective as an antimicrobial than sun dried one. In accordance, Arun & Rao (2011) studied the antimicrobial activity of *Moringa oleifera* extracts by disc diffusion method and showed better activity against the *Proteus mirabitis* isolate and MTCC 442 strain. Also, Peixoto *et al.* (2011) indicated that aqueous and methanolic *Moringa oleifera* leaf extracts were shown to contain compounds with wide spectrum antibacterial activity capable to inhibit the growth of gram-positive and negative bacteria. In addition, Ratshilivha *et al.* (2014) reported that a large variation was not-

Table 5: Antimicrobial activity of *Moringa oleifera* leaves extracts

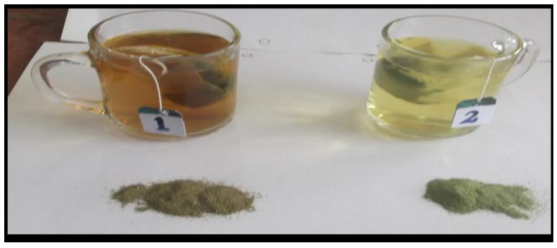
Microorganism	Diameter of inhibition zone(mm)*	
	Sun dried	Dehydrated
Bacillus subtilis	28.00	33.00
Escherichia coli	15.00	22.00
Yeast		
Saccharomyces cerevisiae	30.00	25.00
Mold		
Aspergillus niger	13.00	19.00

*Data are average of duplicate determinations

ed in antimicrobial and antioxidation activity of acetone leaf extract of 12 variety of *Moringa oleifera*.

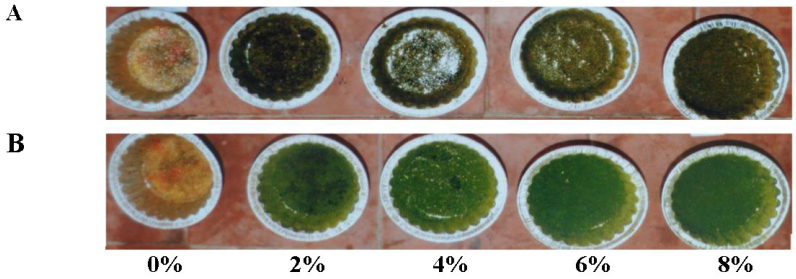
Sensory evaluation of some food products containing sun dried and dehydrated *Moringa oleifera* leaf powder: The general appearance of some food products including moringa tea, vegetable soap, *Quarish* cheese and mashed potatoes that contain different concentrations of sun dried and dehydrated *Moringa oliefera* leaf powder are presented in Fig.(5) .

***Moringa* tea:** The organolyptic properties of moringa tea are given in Table (6). Except taste

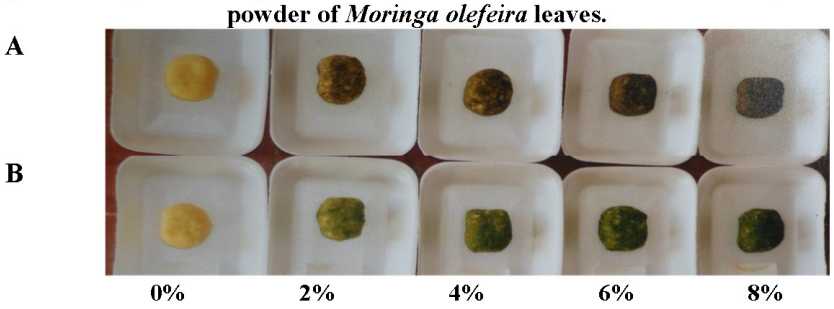


A B

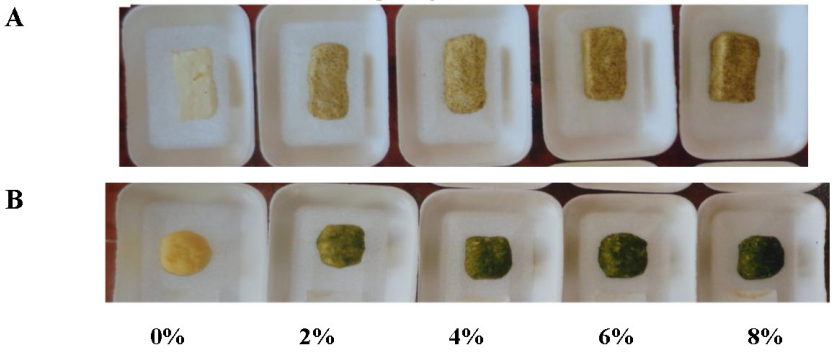
***Moringa olefeira* leaves tea from sun dried and dehydrated powder of *Moringa olefeira* leaves , respectively**



Vegetable soup containing different concentrations of sun dried and dehydrated powder of *Moringa olefeira* leaves.



Mashed potato containing different concentrations of sun dried and dehydrated powder of *Moringa olefeira* leaves.



***Quarish* cheese containing different concentrations of sun dried and dehydrated powder of *Moringa olefeira* leaves .**

Fig.5: General appearance of moringa tea, vegetable soup, mashed potatoes and *Quarish* cheese containing different concentrations of sun dried and dehydrated *Moringa oleifera* leaf powder.

A : Sun dried *Moringa oleifera* leaves B: Dehydrated *Moringa oleifera* leaves

and colour density, no significant differences were noted in the organolyptic attributes of the sun dried moringa tea or the dehydrated ones. The sun dried moringa tea was more acceptable in terms of the taste and colour than dehydrated ones. The two samples of tea were still well accepted by the panelists, because all the arrtibutes were over the numerical value of 7.

Table 6: Organoleptic evaluation of *Moringa olefeira* leaves tea

Attributes	Sun dried *Moringa* leaf Powder	Dehydrated *Moringa* leaf Powder
Colour	8.85^{a}±0.91	8.29^{a}± 1.3
Taste	8.48^{a}±1.19	7.70^{b}±1.32
Odour	7.38^{a}±0.01	7.81^{a}±1.36
Colour density	9.07^{a}±0.73	8.07^{b}±1.29
Appearance	8.67^{a}±0.96	8.26^{a}±1.2
Overallacceptability	8.70^{a}±0.95	8.11^{a}±1.25

Means within a row not sharing the same letter are significantly different at $P \leq 0.05$

Vegetable soup: According to the obtained data in Table (7), except the taste there were a significant effect of source either sun dried or dehydrated moringa on all organoleptic attributes of vegetable soup. On the other hand, the concentrations (%) used were significantly affected all the attributes of vegetable soup. Furthermore, there was a significant interaction between the source and concentration of both the sun dried and the dehydrated *Moringa* leaf powder on the colour, taste, and overall acceptability of the vegetable soup.

The scores of organolyptic attributes given for vegetable soup decreased with increasing the amount of both the sun dried and the dehydrated moringa powder. Except the appearance in case of vegetable soup containing 2% sun dried moringa powder and the taste as well as the overall acceptability of vegetables soup containing 2% dehydrated moringa powder, the other attributes were still accepted by the panellists. Increasing the amount of dehydrated moringa (Table 7) had positive effect on colour, taste and overall acceptability than sun dried ones. Poor and rejected organoleptic attributes were obtained at 8% concentration of both powders.

Mashed potato: There were significant effects of the source of moringa powder (sun dried and dehydrated) on the colour only of mashed potato (Table 8). In addition, the concentration (%) used was found to affect significantly all the attributes of the product. Further, no significant interaction between the source and concentration of moringa powder was traced for all the studied attributes of the final products. It was obvious that panellists accepted mashed potato containing either the sun dried or the dehydrated moringa powder up to 4% concentration, this because the most of the attributes were quite close to the numerical value of 7. At higher concentrations (6 and 8%) the scores

Table 7: Organoleptic evaluation of vegetable soup containing different concentrations of sun dried and dehydrated powder of *Moringa olefeira* leaves

Samples	Colour	Taste	Odour	Texture	Appearance	Overallaccep
Sun dried						
0%	8.25^{a}	8.80^{a}	8.75^{a}	6.95^{a}	7.90^{a}	8.1^{ab}
2%	7.4^{b}	7.90^{b}	7.15^{a}	7.10^{a}	6.95^{a}	7.6^{b}
4%	6.06^{d}	6.65^{c}	6.00^{a}	6.25^{a}	5.85	6.15^{c}
6%	5.02^{e}	5.25^{de}	6.16^{a}	5.65^{a}	5.50^{a}	4.70^{c}
8%	4.5^{f}	3.8^{f}	5.00^{a}	4.70^{a}	4.65^{a}	3.60^{f}
Dehydrated						
0%	7.95^{ab}	8.1^{ab}	8.65^{a}	8.10^{a}	8.35^{a}	8.40^{a}
2%	7.95^{ab}	7.7^{b}	7.35^{a}	7.85^{a}	7.80^{a}	7.40^{b}
4%	7.35^{b}	6.80^{c}	7.10^{a}	7.40^{a}	7.05^{a}	6.60^{a}
6%	6.7^{c}	5.60^{d}	6.20^{a}	6.35^{a}	6.10^{a}	5.60^{d}
8%	5.7^{de}	4.90^{e}	5.35	5.10^{a}	4.75^{a}	4.55^{e}

Means within a column not sharing the same letter are significantly different at $P \leq 0.05$

Table 8: Organoleptic evaluation of mashed potato containing different concentrations of sun dried and dehydrated powder of *Moringa olefeira* leaves

Samples	Colour	Taste	Odour	Texture	Appearance	Overallaccep
Sun dried						
0%	9.58[a]	9.20[a]	9.37[a]	9.20[a]	9.16[a]	9.20[a]
2%	8.04[a]	7.75[a]	8.08[a]	8.50[a]	7.95[a]	8.04[a]
4%	7.04[a]	6.25[a]	6.75[a]	7.41[a]	6.79[a]	6.75[a]
6%	5.83[a]	5.04[a]	5.29[a]	6.45[a]	5.50[a]	5.62[a]
8%	5.33[a]	4.33[a]	4.95[a]	5.66[a]	4.47[a]	4.41[a]
Dehydrated						
0%	9.66[a]	8.95[a]	9.41[a]	9.00[a]	9.00[a]	9.25[a]
2%	8.37[a]	7.75[a]	7.87[a]	8.58[a]	8.04[a]	8.16[a]
4%	7.70[a]	6.54[a]	6.75[a]	7.54[a]	7.20[a]	6.91[a]
6%	6.70[a]	4.87[a]	6.16[a]	7.04[a]	6.41[a]	6.08[a]
8%	5.58[a]	4.66[a]	5.08[a]	5.41[a]	5.08[a]	4.29[a]

Means within a column not sharing the same letter are significantly different at $P \leq 0.05$

given for overall acceptability of mashed potato decreased and were not accepted by the panellists. Also, slight significant differences were noted in the organoleptic attributes between the two different treatments of *Moringa* powder .

***Quarish* cheese:** The organolyptic properties of *Quarish* cheese containing different concentrations of sun dried and dehydrated moringa leaf powder are given in Table (9) . There was a significant effect of the source of moringa powder on the taste only. Moreover, the concentrations used significantly affected all the studied attributes. According to the obtained data (Table 9), the organoleptic attributes of *Quarish* cheese decreased with increasing the amount of moringa powder. Slight significant differences were noted between the sun dried and the hehydrated moringa leaf powder. The *Quarish* cheese samples containing up to 6% of both moringa powders were still accepted by the panellists.

Generally, all the products containing either sun dried or dehydrated moringa leaf powder were more acceptable in taste and colour, respectively.

Table 9: Organoleptic evaluation of *Quarish* cheese containing different concentrations of sun dried and dehydrated powder of *Moringa olefeira* leaves.

Samples	Colour	Taste	Odour	Texture	Appearance	Overallaccep
Sun dried						
0%	9.23[a]	7.76[a]	8.80[a]	8.70[a]	8.86[a]	8.73[a]
2%	8.26[a]	8.16[a]	8.13[a]	8.30[a]	8.46[a]	8.26[a]
4%	7.83[a]	7.46[a]	7.80[a]	8.30[a]	8.03[a]	7.86[a]
6%	7.16[a]	6.93[a]	7. 23[a]	7.56[a]	7.06[a]	6.90[a]
8%	6.46[a]	6.23[a]	6.60[a]	7.33[a]	6.96[a]	6.60[a]
Dehydrated						
0%	9.16[a]	8.73[a]	8.63[a]	8.76[a]	8.90[a]	8.83[a]
2%	8.06[a]	7.66[a]	7.96[a]	8.23[a]	8.40[a]	8.06[a]
4%	7.56[a]	6.90[a]	7.40[a]	8.10[a]	7.96[a]	7.40[a]
6%	7.06[a]	6.66[a]	7.06[a]	7.93[a]	7.47[a]	7.23[a]
8%	6.43[a]	5.66[a]	6.26[a]	7.13[a]	6.70[a]	6.33[a]

Means within a column not sharing the same letter are significantly different at $P \leq 0.05$

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دراسات كيماوية وتكنولوجية على أوراق نبات المورينجا ومستخلصاتها الفينولية

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الهدف من هذه الدراسة هو معرفة التركيب الكيماوى ومحتوى المعادن و تركيب الأحماض الدهنية والمركبات الفينولية و النشاط المضاد للأكسدة و النشاط المضاد للميكروبات بالإضافة إلى إمكانية الاستفادة من أوراق المورينجا المجففة طبيعياً أو صناعياً فى تحضير بعض المنتجات الغذائية. أوضحت النتائج وجود اختلافات جوهريه بين مسحوق الأوراق المجففة طبيعياً وتلك المجففة صناعياً من حيث محتواها من المستخلص الإثيرى الخام و الكربوهيدرات وبصفة عامة تعتبر هذه الاوراق مصدراً جيداً لبعض العناصر المعدنية الكبرى مثل الكالسيوم والبوتاسيوم والصوديوم والمغنيسيوم. والأحماض الدهنية المشبعة وغير المشبعة الأكثر شيوعا فى زيت هذه الأوراق هى البالمتيك والأوليك واللينولينك واللينوليك على الترتيب. أوضحت النتائج إحتواء الأوراق الجافة على كميات مرتفعة من المركبات الفينولية وحامض الأسكوربيك كما تميزت بنشاط مضاد للأكسدة حيث تراوحت قيم هذه المكونات من ٣٨,٠٧- ٤٣,٠٢ مجم/جم ، من ١٥,١٠- ٢٠,٤٣ مجم/ ١٠٠جم و من ٧٩,٩٢- ٨٣,٤ ٪ لمسحوق الأوراق المجففة طبيعيا أو صناعيا على الترتيب. تم التعرف على الأحماض الفينولية التالية فى كلا المستخلصين موضع الدراسة: الجاليك، الكلوروجينك، الايلاجيك، الفيريوليك وذلك عند فصلهما باستخدام كروماتوجرافياً، السائل عالية الإظهار HPLC وأظهرت مستخلصات كلتا العينتين نشاطا ملحوظا ضد الميكروبات التاليه :-

Bacillus subtilis, Saccharomyces cereviaiae, Escherichia coli, Aspergillus niger

كما أظهرت النتائج أن جميع المنتجات المحتوية على مسحوق أوراق المورينجا المجففة طبيعياً أو صناعياً كانت مقبولة من حيث خواصها الحسيه خاصه اللون و الطعم.