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Morphological and Analytical characterization of *Moringa peregrina* Populations In Western Saudi Arabia

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ABSTRACT: The purpose of this study was to assess phenotypic variations and determine the types and levels of major nutrients in the seeds and leaves of *Moringa peregrina* (Forssk.) Fiori as a potential multipurpose crop in arid environments . The experimental work was conducted on seven Moringa populations. Five of these were natural stands located in the north west of Saudi Arabia and the other two were raised in irrigated farms located in the in central part of Red Sea coast . Tree height, stem diameter at BDH, pods length, pod weight, number of seeds per pod, weight of seed per pod, 100 seed weight, kernels oil and protein contents, fatty acid composition, amino acid composition of seeds and dry leaves and culms and macro and micronutrients in the leaves and the kernel were determined. The Moringa population in Ssgoon valley had significantly the longest pods (29.3 cm). Significant interactions between years and valleys were observed for each of the studied traits. Pod length was negatively correlated to weight of seed / pod, whereas gross pod weight was positively correlated to number of seeds / pod, weight of seeds / pod and 100 seed weight. Oil percentage in the seed, across locations, ranged from 54.29% to 57.25%, whereas protein content ranged from 11.7 % to14.6%. The results revealed that both culms and dry leaves are good sources of protein and essential minerals comparable to those recorded for *Moringa oliefera*. Out of the 17amino acids found in leaves and seeds, 9 were classified as essential amino acids. Fatty acid profiling of the seeds showed that of the 9 fatty acids identified in the seeds 5 were classified as the saturated. Oleic (53.94% to 64.19%), palmitic (12.89 % to 17.88) and stearic (6.63 to 11.51) acids were present in relatively the highest amounts.

Key words: *Moringa peregrine,* Protein Oil, Minerals Population

I. INTRODUCTION

Moringa peregrina [(Forssk.) Fiori] belongs to a monogeneric family of shrubs and tree, Moringaceae. It can grow well on hillsides. Moringa is a fast growing, perennial tree which grows naturally at elevations of up to 1,000 m above sea level an can reach a maximum height of 7-12 m and a diameter of 20-40 cm at chest height.

Although, it is a rare species, *M. peregrina* has a wide geographic range, growing from the Dead Sea area sporadically along the Red Sea to northern Somalia and around the Arabian Peninsula to the mouth of the Arabian (Persian) Gulf, Red sea coast Sinai Mountains (Täckholm, 1974; Boulos, 1999). Because of the severe drought and the over-exploitation of seeds for oil extraction and tree cutting for firewood and fodder, the species is threatened. Its presence is almost restricted to northwest and northeast sectors of the Red Sea (Hegazy *et al*., 2008).
Moringa peregrina could soon become one of the arid land's most valuable plants, at least in humanitarian terms and in animal feeds. Its seeds have different economic and medicinal importance due to its unique composition of oil, proteins fiber, carbohydrates and ash contents (Somali *et al*., 1984 and Al kahtani, 1995). The leaves are excellent source of vitamins, minerals, proteins and a very low source of fat and carbohydrates. Both leaves and pods supply several amino acids, including the sulfur-containing amino acids methionine and cystine, which are often in short supply in the Bedouin diet (Makkar and Becker, 1996).

Apparently *Moringa peregrina* is more drought tolerant than *M. oleifera* which is commercially planted in a large scale in tropical and sub tropical areas. Until now a full characterization and comparison of nutritional components in seeds and leaves of the wild *Moringa peregrina* is not been reported. This work examines its potentialities of *Moringa peregrina* a future crop in arid and semi arid regions.

II. MATERIALS AND METHODS

A. Locations

In conducting this study, five valleys (Wadis) namely Um Adood, Sagoom, Gitaan , Thari and Kideda were selected from North West region of Saudi Arabia in an area extending between Lat:26° 10' 17" and 28° 42' 24" N and Long:35° 17' 30" and 37° 26' 32" E. These valleys are known to be among the richest valleys in wild trees stands of Moringa *peregrina* in the specified region and in the Kingdom. In addition, Moringa plantations in two irrigated farms Hada Asham (Lat: 21° 46' and Long: 39° 39' 31") and Al Bowair (Lat:24° 56' ' and Long: 39° 00' 06") were included in the study. Tables 1 and 2 show the meteorological data of two sites within the study area where Moringa stands grow naturally.

Table 1 . Meteorological data for Tabuk city a site representing the prevailing climatic features in the northern ecosystem of the study area.

Tabuk: Lat: 28 22 35N Long: 36 36 25E Elevation 768.11 M								
	Temperature(° C)			Relativr humidity (%)			Vapor pressure (hPa)	Precipitation (mm)
Month	Max	Mim	Mean	Max	Mim	Mean		
1	20.5	6.3	13.4	96	5	47	6.9	38.8
2	23.1	9.1	16.4	90	7	36	6.5	3.2
3	26.2	10.8	18.7	79	5	28	5.5	0.0
4	30.3	15.6	23.3	65	7	24	6.2	2.3
5	34.5	19.5	27.0	90	5	22	6.9	2.5
6	37.9	22.8	30.6	58	6	20	7.8	0.0
7	40.4	25.5	33.2	47	6	19	8.8	0.0
8	40.4	26.1	33.2	55	7	22	10.1	0.0
9	36.7	22.4	29.5	62	7	26	9.8	0.0
10	33.3	18.1	25.7	71	8	27	8.0	0.0
11	25.0	10.3	17.4	78	7	30	5.7	0.0
12	20.4	5.9	12.8	95	8	38	5.4	2.2

Table 2. Meteorological data for Al Wajh city a sites representing the prevailing climatic features in the central ecosystem of the study area.

	Temperature (°C)			Relative humidity (%)			Vapor pressure (hPa)	Precipitation (mm)
Month	Max.	Mim.	Mean	Max.	Mim.	Mean		
1	22.6	15.6	20.7	92	16	65	15.8	24.0
2	26.8	16.7	21.8	94	25	60	15.8	0.0
3	28.9	18.2	23.5	84	13	53	15.5	0.0
4	30.7	20.4	25.5	92	16	61	18.8	0.0
5	31.9	22.1	27.4	96	20	66	23.6	0.0
6	33.8	24.4	29.6	100	15	68	27.5	0.0
7	34.8	26.4	30.7	98	25	74	31.7	0.0
8	35.4	26.8	31.3	96	24	74	33.3	0.0
9	34.1	24.8	29.6	100	22	76	30.7	0.0
10	34.0	23.6	28.8	97	9	66	26.0	0.0
11	31.8	19.2	25.194	87	10	49	15.8	0.0
12	28.1	16.3	22.920	97	8	54	14.0	47.5

B. Botanical Description

This study was conducted on Moringa plants that emerged after direct seeding under farm conditions. Growing plants were monitored until fruit set and seed maturity. In the course of the study, flowers and mature seeds samples, taken to the laboratory and observed under the light microscope and a digital camera.

C. Phenotypic variations in height and stem diameter

Forty trees were randomly selected from each of (Umadood, Sagoom, Gitan and Thari valleys in years 2009, 2010, and used to estimate tree height and stem diameter at breast height (BDH).

D. Flowering and fruit set

Data on flowering and fruit set was recorded from 40 trees randomly selected in each of five valleys (Umadood, Sagoom, Gitan, Thari and Kidded) on Mid April and Mid May in years 2009 and 2010 respectively.

E. Pod and seed characteristics

Forty mature pods, harvested from 160 fruiting trees (40 per location) from three valleys (Umadood, Sagoom, Gitan) and Al Bowair irrigated farm, were used for assessing pod and seed characteristics including oil and protein contents.

F. Chemical components

Seed samples collected from Umadood, Sagoom, Gitan Al Bowair and Hada Asham irrigated farms were utilized in the determination of nutrient components (Amino acids, fatty acid and minerals) in the Moringa seeds. Nutritional components and minerals in the leaves and culms were estimated from plant samples collected from the irrigated field in Hada Asham farm. The determination of the chemical components was as follows: Oil extraction from clean, dried, dehulled and crushed seeds was carried out using a 5-LSoxhlet extractor assembly by using petroleum ether (BP 40–60°C). Crude protein content of seed residues (N* 6.25), after the oil extraction as well as that of the dried leaves and culms, was determined was determined by the Kjedahl method (AOAC, 1990). Other components in the dried leaves and culms were determined as follows: Ash and crude fiber contents were done according to Pomeranz and Meloan (1994). Macro and microelements were determined according to the method of AOCA (1990). Amino acid profile in seeds, dried leaves and culms was carried out as suggested by Moore (1958), whereas and fatty acid composition was determined by gas–liquid chromatography (GLC) according to the method of Radwan (1978).

G. Statistical analysis

Data on stem height and pod characteristics recorded for the first four locations in years 2009 and 2010 were analyzed as for a completely randomized design with years and locations as factors. Simple correlations to examine interrelations among the studied traits were calculated. Each nutrient analysis was done in triplicate. Data obtained was processed using SAS proc means (2003) which computed the means and relevant standard deviations (SD) and/or SE and coefficient of variations (CV).

III. RESULTS AND DISCUSSION

A. Botanical Description

Field observations showed that the young seedlings have broad leaflets (Fig.1 A) and form a large tuber under the ground (Fig.1B). As the plant gets older, the leaves get progressively longer (Fig.1C), while the leaflets get smaller and more widely spaced (Fig.1D). Adult trees produce leaves with a full complement of tiny leaflets, only to drop them as the leaf matures. However, the naked leaf axes remain, giving the tree a wispy look similar to *Tamarix* spp. The naked leaves are alternate, in bunches at the ends of branches, 15–40 cm long, 2–pinnate, with 2–5 pairs of pinnae; leaflets opposite or alternate, obovate, oblanceolate or spatulate, 3–20(–35) mm × 2–10(–13) mm, base cuneate to rounded, apex rounded or notched, grey or waxy green. The flowers (Fig. 2A), which are pleasantly fragrant and 2.5 cm wide, are profusely produced in axillary, drooping panicles 10 to 25 cm long (Fig.2B). They are white or cream colored and yellow-dotted at the base. The five-reflexed sepals are linear-lanceolate. The five petals are slender-spatulate and reflexed except for the lowest. These petals surround the five stamens and the five staminodes.

The fruit (Fig.1C) an elongate capsule (10–) 32–39 cm × (1–) 1.5–1.7 cm, somewhat trigonous, slightly narrowed between the seeds, with a beak, glabrous, dehiscent with 3 valves. Seeds (Fig.1D) globes to ovoid or trigonous, 10–12 mm × 10–12 mm, brown. These observations are in accordance with earlier reports of Collenette (1985) and Olson (2003) who studied the botany and flower morphology of *Moringa peregrina* in more details.

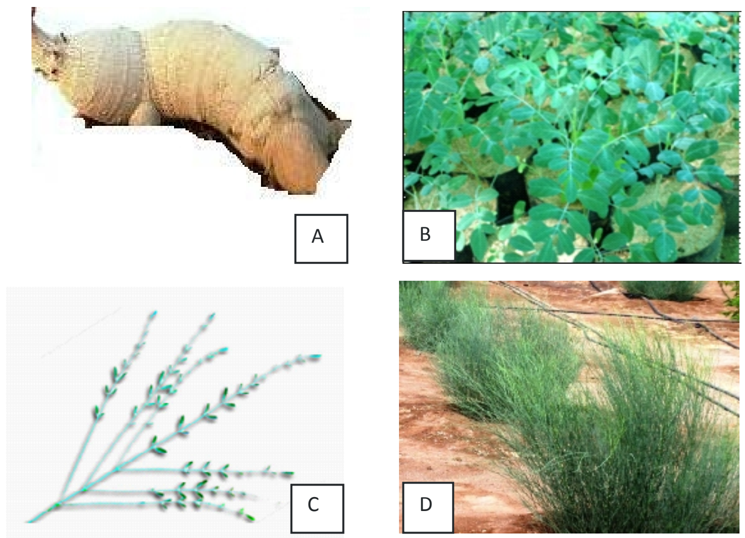

Fig.1. Vegetaive parts :A. Tuberous root; B.seedling leaves ; C.Mature leaf ; D. Regrowth

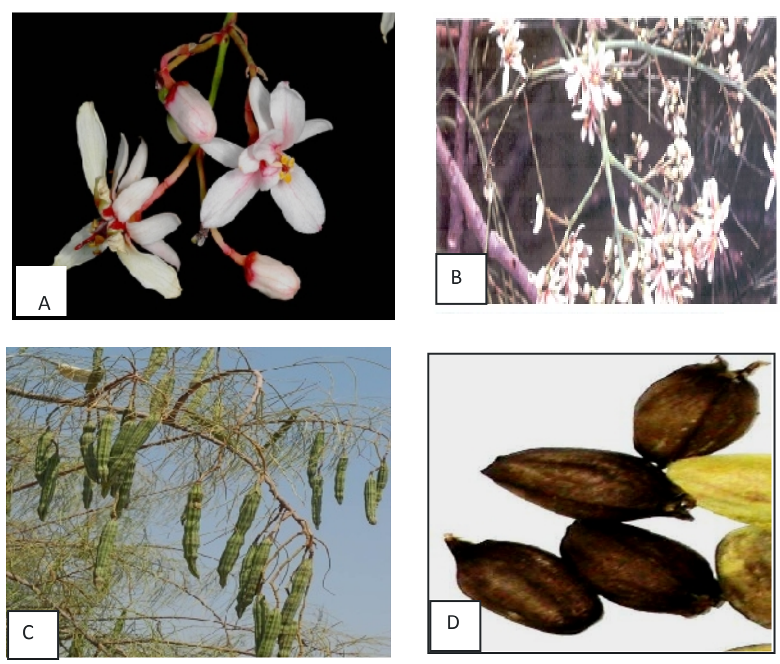

Fig. 2. Reproductive parts: A. individual flowers ; B.Infloresence ; C.Mature se
D. mature pods.

B. Phenotypic variations in height and stem diameter

Average height of the 40 trees recorded at Thari was significantly ($P \leq 0.01$) higher than that record at the other valleys (Table 3). Estimates of stem diameter at breast height at Thari significantly ($P \leq 0.01$) excelled those recorded for trees in each of the other three valleys. Plant height and stem diameter were highly and positively correlated (r = 0.574**) to one another and their joint contribution in the total phenotypic variability (33%) was highly significant (R2 = 0.33**).

Table 3. Plant height and diameter in year 2009.

	Height(m)				**Stem diameter at BDH(cm)**			
	Um adood	**Sagoom**	**Gitaan**	**Thari**	**Um adood**	**Sagoom**	**Gitaan**	**Thari**
Range	1.5-9	9-3	1.5-13	17-4	5.7-22.3	6.0-28.3	4.8-39.1	10.8-47.7
Mean	4.6±1.9	7.0±2.5	6.0±3.2	9.3±2.7	11.9±3.9	15±5.6	12.8±7.6	26.8±8.8
SE	1.24**				3.18**			
C.V,(%)	41.7	35.9	53.6	29.3	32.7	37.3	59.8	32.9

** Indicate significant difference at the % level.

Apparently, local measures taken by the tribe resident in Thari to guard the Moringa populations against overgrazing and tree cutting had contributed to its excellence over the other valleys.

C. Flowering and fruit setting

The percentage of trees that flowered in the studied valleys ranged from 17.6-95.6% in first year and from to 42.5-82.5% in the second year with overall averages of 66.08 and 67.5 % in the respective years. Out of 160 trees studied only 3.9 %, in the first year, and 42.0%, in the second year, had borne fruits (Table 4). This indicates *Moringa peregrina*, like many desert tree species, has an alternate bearing habit.

Table 4. Percentage of flowering and fruit setting in years 2009 and 2010.

	Year (2008/2009)			**Year (2009/2010)**		
	Percentages of trees in:			**Percentages of trees in:**		
	Flowering	**Non flowering**	**Fruiting**	**Flowering**	**Non flowering**	**Fruiting**
Thari	76.6	23.8	2.3	82.5	17.5	30
Gitan	75.6	25.4	9.1	60	40	42.5
Kideda	65	35.0	7.7	80	20	50
Sagoom	95.6	3.4	3.1	72.5	27.5	60
Um adood	17.6	82.4	0	42.5	57.5	27.5
Mean	66.08	34.00	4.44	67.50	32.50	42.00
SD±	29.26	30.97	3.82	16.49	30.97	13.62
C.V(%)	44.28	91.08	86.08	24.43	95.29	32.44

D. Pod characteristics

On the average, the Moringa population in Sagoon valley had significantly ($P \leq 0.01$) longer pods than those recorded for each of the other three populations (Table 5). Significant differences ($P \leq 0.01$) between years were observed for number of seeds (Table 5) and for weight of seeds per pod (Table 6).

Table 5. Pod length, gross pod weight and number of seeds/pod in years 2009 and 2010.

	Pod length (cm)			**Gross pod weight(cm)**			**Number of seeds/pod**		
Year Location	**1st year**	**2nd year**	**Mean**	**1st year**	**2nd year**	**Mean**	**1st year**	**2nd year**	**Mean**
	±0.55**		±0.39	±0.41**		0.29	±0.44**		± 0.31
Sagoom	25.8	32.7	29.3	10.9	8.0	9.5	12.1	12.9	12.5
Um adood	29.6	23.3	26.5	10.3	10.8	10.6	11.9	11.9	11.9
Gitan	23.1	24.1	23.6	9.2	13.1	11.1	11.9	10.9	11.4
Al Bowair	21.0	18.1	19.6	9.9	10.0	10.0	12.4	9.5	11.0
S.E ±	0.27			0.20			0.22**		
Mean	24.9±4.5	24,5±6.2		10.1±2.2	10.5±2.1		12.1±2.7	11.3±3.1	

** Indicate significant difference at the % level.

Table 6. Weight of seeds/pod, 100 seed weight, oil and protein contents in seeds in years 2009 and 2010.

	Weight of seed/pod			**100 seed weight (g)**			**Oil (%) content**	**Protein content (%)**
Year location	**1st year**	**2nd year**	**Mean**	**1st year**	**2nd year**	**Mean**	**First season**	**First season**
	±0.23 **		±0.17	± 2.38. **		±1.69		
Sagoom	4.4	6.4	5.4	49.5	55.3	52.4	55.43	12.5
Um adood	3.6	4.5	4.0	48.9	40.0	44.4	54.29	12.7
Gitan	4.1	6.2	5.2	51.9	53.7	52.8	57.25	11.7
Al Bowair	5.7	4.9	5.3	59.7	52.0	55.9	55.33	14.6
S.E±	0.12**			1.19			0.614	0.615
Mean	4.5	5.5		52.5.6	50.2		55.6	12.9

** Indicate significant difference at the 1% level.

Significant interactions between years and valleys were observed for each of the studied traits, indicating that not all trees in each of the four sites behaved in a similar trend in each year. Pod weight and individual seed weight recorded in this study were higher than those reported by Makkar and Becker (1997) and Ayerza (2011) for *Moringa oliefera* but lower than those reported by Al khatani (1995)**.** On the other hand, number of seeds per pod are comparable to those reported by and Ferrao (1970) for *M. oliefera* and by Al khatani (1995) for *M. peregrina*. Data in Table 7 revealed that pod length was negatively correlated (r =- -0.5058**) to weight of seed/pod, whereas gross pod weight was positively correlated (r = 0.2660**) to number of seeds / pod, weight of seeds /pod (0.6055**) and 100 seed weight (0.2480**). Thus, mass selection for heavier pods that are likely to have more mature big seeds, unlike that for longer pods, is likely to improve seed yield under the natural arid environments prevailing in the region.

E. Chemical components

(i) Oil and protein contents

Oil percentage in seed across the four locations ranged from 54.29% 57.25%, whereas protein content ranged from 11.7 % to14.6% (Table 6). Estimates of oil content observed in this study are similar to those reported by Somali *et al*. (1985) and Al khatani (1995) but higher than those reported by Taskins (1999) for *M. Peregrina* and those reported by Ayerzya (2011 and 2012) for *M. oliefera*.

On the other hand, the protein contents were lower than those reported by each of the previous workers. Studies conducted elsewhere (e.g. Lalas and Tsaknis 2002; Anwar and Rashid, 2007) indicated that estimates of oil contents in *M. oliefera* seeds are lower, whereas those of protein are relatively higher than those recorded *for M. peregrina* populations evaluated in the present study.

Table 7. Inter-relationship among pod and seed characters.

	100 seed weight(g)	**Weight of seed/pod(g)**	**Number of seeds/pod**	**Gross pod weight(g)**
Pod length (cm)	0.0351	-0.5058**	0.1119	**0.0668**
Gross pod weight (g)	0.2480**	0.6055**	0.2660**	
Number of seeds/pod	0.0578	0.0924		
Weight of seed/pod	0.0727			

** Indicate significant difference at the 1% level.

(ii) Amino acids composition

In this study 17 amino acids were identified in the dry culms and leaves powder of *Moringa peregrina* (Table 8). In previous studies, 18, 16 and 19 amino acids were reported by Foidl *et al*. (2001), Sanchez-Machado *et al*. (2009) and Moyo *et al*. (2011), respectively. Only araganine, alanine and trptophane were not detected from the common 20 amino acids. Out of the 17amino acids observed, 9 were classified as essential amino acids, namely threonine, methionine, lysine. leucine, isoleucine, valine, phenylalanine, histidine and arginine.

Sanchez-Machado *et al*. (2009) reported that leucine had the highest value of 1.75 (g/16g N) which is lower than 4.74(g/16g N) observed in the present study. Findings from this study showed the presence of proline and cysteine both of which were detected in Sanchez-Machado *et al.* (2009) work. In this study, least values were recorded for histidine, serine and methionine. In previous studies, lowest estimated were recorded for cystine and proline followed by methionine (Moyo *et al*. 2011). Methionine a commonly deficient in green leaves and cystine are powerful antioxidants that help in the detoxification of harmful compounds and protect the body from harmful radiations (Brisibe *et al*., 2009). On the average amino acid contents of seeds observed in this study (Table 8) are higher than those reported by Fugile (2001); whereas those of the dried powder are lower than those reported by (Zarkadas *et al*., 1995) for leaf powder in *Moringa oliefera*.

Table 8. Amino contents (g/16g N) in seeds and dry leaf and stem powder (2009).

	Seeds						Leaf and stem powder
Amino Acid	**Wadi Um dood**	**Wadi Gitan**	**Wadi Sagoom**	**Al Bowair Farm**	**Hada Asham Farm**	**Mean ±SD**	**Hada Asham Farm**
Aspartic	3.95	4.39	3.66	5.12	4.87	4.40±0.61	4.2
Threonine	5.72	1.91	7.86	7.83	5.22	5.71±2.44	1,63
Serine	3.92	2.01	5.39	5.36	3.58	4.05±1.41	1,51
Glutame	15.91	15.39	18.07	17.91	23.41	18.14±3.18	4.06
Proline	2.49	3.54	2.57	7.68	2.28	3.71±2.27	3.02
Glycine	2.95	3.19	3.31	3.97	4.67	3.62±0.70	1.87
Alanine	2.11	2.03	2.24	1.5	2.38	2.05±0.34	2.62
Cystine	0.1	0.41	0.09	0.57	0.54	0.34±0.23	1,87
Valine	2.84	3.9	2.83	2.24	3.09	2.98±0.60	2.95
Methionine	1.21	3.58	0.83	0.62	0.55	1.36±1.27	0,36
Isoleucine	2.58	2.33	2.51	2.43	4.34	2.84±0.84	4,66
Leucine	5.04	4.86	5.35	4.71	7.25	5.44±1.04	4,74
Tryosine	1.64	1.53	1.6	1.52	1.74	1.61±0.09	1.63
Phenyalanine	2.62	3.92	3.7	2.36	4.03	3.33±0.78	2.75
Histidine	2.65	2.11	5.3	3.9	4.1	3.61±1.26	1,55
Lysine	2.03	2.97	4.12	1.55	3.1	2.75±1.00	2,91
Arginine	11.35	8.25	10.95	9.3	14.06	10.78±2.22	2.67

Variations in the amino acid composition could be influenced by protein quality and the origin of the plant (cultivated or wild). Usually cultivated plants are fertilized, which could influence the quality of proteins (Sanchez-Machado *et al*., 2009).

(iii) Fatty acids composition

This study identified 9 fatty acids in the seeds of *M. peregrina* of which 5, namely lauric, myristic, palmitic, stearic and arachidic are classified as saturated (Table 9). Data in table 9 revealed that *M. peregrina* seeds contain relatively highest amounts or oleic acid, palmitic and stearic acids. Overall ranges across the studied populations were 53.94% to 64.19%, 12.89% to 17.88 and 6.63 to 11.51 for the respective acids. Other vegetable oils normally contain only about 40 % oleic acid.

Data in Table 9 revealed that, except for the oleic acid, all other acids were relatively higher than those reported by Somali *et al*. (1985), Al khatani (1995) and Tsakns (1998) for *M. peregrina* seeds collected from Saudi Arabia.

On the other hand, estimates of total saturated fatty acids in this study ranged from 28.06 % to 32,53, whereas total unsaturated fatty acids ranged from 67.47 to 71.94%. Estimates of 14.7% 84.7% (Somali *et al*. 1985) and of 70.4% to 29.6 % (Tsakns, 1998) for total saturated and unsaturated, respectively, were reported for *M. peregrina* in Saudi Arabia. *M. oliefera* contains approximately 13 % saturated fatty acids and 82 % unsaturated fatty acids (Foidl *et al*., 2001). Low content of polyunsaturated fatty acids (<1%) are reported to give to the oil a remarkable oxidative stability (Lalas and Tsaknis, 2002; Kleiman *et al*., 2008).

Variations among Moringa populations in fatty acids composition observed in this study may be attributed to local conditions prevailing in the different locations and / or to the maturity stage at which the pods are harvested. On the basis of the results obtained, the fatty acid composition of *M. peregrina* seed oil showed that it falls in the oleic acid oil category (Sonntag, 1982).

Table 9. Fatty acids contents (%) in seeds (2009).

Fatty acid	Carbons	Sagoom	Um dood	Gitan	Hada Sham	AlBowair	Mean±SD
Lauric	C 12: 0	0.27	0.57	0.24	0.28	0.19	0.31±0.15
Myristic	C 14: 0	0.43	0.80	0.65	0.77	0.47	0.62±0.171
Palmitic	C 16: 0	16.10	12.89	14.69	17.88	15.15	15.34±1.84
Palmitoleic	C 16: 1	4.91	3.19	5.22	5.68	5.77	4.95±1.05
Stearic	C 18: 0	10.12	10.16	10.34	6.63	11.51	9.75±1.84
Oleic	C 18: 1	56.29	64.19	55.81	57.44	53.94	57.53±3.93
Linoleic	C 18: 2	2.70	1.95	3.08	3.69	4.15	3.11±0.86
Linolenic	C 18: 3	4.29	2.64	3.36	3.12	3.66	3.42±0.62
Arachidic	C 20:0	4.91	3.65	6.53	4.51	5.13	4.94±1.05
		Total Fatty Acids					
Saturated		31.86	28.06	32.53	30.07	32.479	31.00±1.92
Unsaturated		68.19	71.94	67.47	69.93	67.521	69.01±1.92
Mono-unsaturated		61.2	67.38	61.04	63.12	59.708	62.49±2.99
Poly-unsaturated		6.99	4.56	6.43	6.82	7.81	6.52±1.21

(iii) Proximate analysis of leaves and culms

Data in Table 10 revealed that the leaves contain 23.31 proteins, 5.81% fat, 6.39% fiber and 1.72% ash. Estimates in the culms were 15.19, 4.42, 17.73 and 11.90% for the respective components. The values of protein obtained in the leaves of *M. peregrina* in this study were generally higher the average values found in the reports of (Verma *et al*., 1976; Elkhalifa *et al*., 2007) but lower than those reported by (Fugli, 2001; Oduro and Owusu , 2008). They are similar to those reported by Ongrungruangchok *et al*.(2010) and Moyo *et al.* (2011). The fat content was higher than the values reported by (Elkhalifa *et al*., 2007; Oduro and Owusu, 2008) but lower than those reported by Moyo *et al.(*2011). The crude fiber in leaves is lower than that reported by Fugile (2001); Oduro and Owusu (2008) and Ongrungruangchok *et al*. (2010). However, it is higher than that reported by (Verma *et al*., 1976; Elkhalifa *et al*., 2007). The ash of the leaves was lower than those reported by each of the previous workers. Apparently, no proximate analysis work was conducted elsewhere to assess the contents of the culms in Moringa.

Data in Table 10 revealed that the leaves contain calcium (2390 mg/100g), phosphorus (190 mg/100g), magnesium (530 mg/100g), potassium (3500 mg/100g), sodium (1090 mg/100g), sulphur (630 mg/100g). Moyo *et al*. (l 2011) reported estimates of 3650, 300, 500, 1500 and 164 mg/100g) for the respective elements in the dried leaves of *M. oliefera*. Estimates of 1950, 180, 450, 4180.and 2430 mg/100g were found in the culms (twigs with no leaves) for the respective elements (Table 10). Estimates of Ca and K in leaves were higher than those reported by Verma *et al*. (1976) and Oduro and Owusu (2008). Other studies (Anjorin *et al*., 2010) reported that Ca ranged from 2.801-3.734 mlL^{-1} in leaf petiole and from 3.463 to 3.827 mlL^{-1} in lamina ; whereas Mg ranged from 0.693 to 0.830 mlL^{-1} and from 0.725 to 0.806 mlL^{-1} in the respective parts of *M. oliefera* leaves.

Table 10. Proximate analysis, macro and micro elements in dry leaves and culms.

	Micro element (mg/kg)			**Macro elements (g/kg)**	
Element	**Leaves**	**Culms**	**Element**	**Leaves**	**Culms**
Cu	7.86	8020	Na	10.9	**10.7**
Fe	844.6	502.5	P	1.9	**1.8**
Mn	177.9	67.03	K	35.0	**41.8**
Zn	22.08	21.29	Ca	23.9	**19.5**
			Na	37.3	**24.3**
			Mg	5.3	**4.5**
Proximate analysis					
Crude fat (%)	5.81	4.42	Crude protein	23.31	**15.19**
Total ash(%)	1.72	11.90	Crude fiber	6.39	**17.73**

Among the micro-minerals, Fe recorded the highest value (844.6 mg/kg) followed by Mn (177.90 mg/kg). Zinc (22.08mg/kg). Copper had the least value of 7.86 mg /kg (Table10). Estimates of 802.0, 502.2, 21.29 and 67.03 mg/kg for the respective elements in the culms. Moyo *et al*. (2011) reported average values of 490.0, 86.8, 1.303 and8.25 mg/kg for the respective elements in *M. oleifera* dried leaves. Anjorin *et al*.(2010) reported that Fe ranged from 0.047 to 0.144 mlL^{-1} in leaf petiole and from 0.041 to 0.079 mlL^{-1} in the lamina; whereas Cu ranged from 0.028 to 0.035 mlL-1 and from 0.0436 to 0.0440 mlL^{-1} in the respective parts of *M. oliefera* leaves.

(v) Nutritional components of seeds

Data in Table 11 revealed that the concentrations of macro elements in the kernels of a mature seed among the five locations ranged from124.8 to 132.9, from 22.00 to 29.00 and from 4.00 to 5.10 mg /100 g for P, K and Na, respectively. Ranges from 0.377 - 0.510, 0.078 - 0.093, 0.034 to 0.315 and from 0.103 to 0.224 mg /l were recorded for Ca, Mg, Cu and Fe, respectively. Anjorin *et al*. (2010) reported ranges of 1.029 -1.416 mlL^{-1} and 0.765 -0.838 mlL^{-1} for Ca and Mg respectively. Anjorin *et al*. (2010) reported ranges of 0.015-0.034 for Cu and 0.075-0.119 for Fe in the seed kernel of *M. oliefera*.

Table 11. Macro and micro elements in seed kernels.

	Macro- elements					**Micro-elements**	
	P	K	Na	Ca	Mg	Cu	Fe
Locatiobn	Mg/100ml			Mg/l			
Sagoom	124.80	22.00	4.10	0.510	0.083	0.315	0.143
Um Adood	141.10	29.00	5.10	0.481	0.086	0.036	0.224
Gitan	124.80	21.00	4.20	0.565	0.082	0.044	0.169
Hada Asham	132.90	22.00	4.00	0.377	0.078	0.056	0.136
Al Bowair	132.90	22.10	4.20	0.464	0.093	0.034	0.103
Mean	131.30	23.22	4.32	0.479	0.084	0.097	0.155
SD	6.81	3.26	0.44	0.069	0.005	0.122	0.045
CV (%)	5.19	14.05	10.27	14.400	5.942	125.721	29.055

Variations in the nutritional values in plant species differ for a wide range of reasons, such as cultivation regions, growing conditions, nature of soil, seasonal changes, genetical different and/ or storage conditions (Ongrungruangchok *et al*., 2010). Considerable variations among the nutritional values of Moringa species were attributed to genetic background, environment and cultivation practices (Brisibe *et al*., 2009).

This study indicates that *Moringa peregrina*, an undomesticated species that naturally grows in harsh environments, is an excellent source of oil, proteins fiber, carbohydrates and minerals. Both leaves and pods supply several amino acids, including the sulfur-containing amino acids methionine and cystine, which are often in short supply in the Bedouin diet.

This excellence was maintained under both natural and irrigated conditions in the arid ecosystem of the northwest and central west regions of Saudi Arabia and its comparable to that recorded for *M. oliefera* that is commercially planted in tropical areas. As no actual seed yield or dry matter data is recorded in the course of this work, additional studies are needed to determine factors affecting Moringa seeds and fodder yields, including agronomic practices and selection for high yielding genotypes before making any recommendation about the economic potential of *Moringa peregrina* as a new crop for the Western region.

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