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Current Status of Economically Important Plant *Moringa peregrina* (Forrsk.) Fiori in Saudi Arabia: A Review

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ABSTRACT: One of crucial issues that are faced by global community is hunger and food insecurity. *M. peregrina* is a promising candidate for future crop, especially in arid regions where food insecurity prevalence is high. The tree is known to be drought resistant and have very valuable nutrient and medicinal properties. Saudi Arabia is one of the main native distribution areas of *M. peregrina* in the Middle East. In this paper, the current status of *M. peregrina* in Saudi Arabia is reviewed. In the last decades, the study on *M. peregrina* in Saudi Arabia has increased, leading to better understanding on its distribution and ecology, nutrient content from its various parts and their medicinal properties. The paper also discusses conservation status of *M. peregrina* and further studies needed to support the conservation of this very valuable tree.

Keywords: *Moringa peregrina*, Saudi Arabia, medicine, nutrient, conservation

I. INTRODUCTION

One of fundamental glitches facing global community is hunger due to food scarcity. A very recent report by FAO, IFAD and WFP (2013) estimated that a total of 842 million people are suffering from choric hunger. This means that around one in eight people in the world unable to meet their need of enough food for an active and healthy life. Developing countries hold the highest proportion of hungry people with the prevalence of 14.3 % or around 827 million people. There are several factors that lead to this hunger problem which include poverty, lack of investment in agriculture, climate and weather, war and displacement, unstable market and food wastage (WFP 2014; http://www.wfp.org/hunger).

Food availability plays a major role in eradicating hunger and ensuring food security. As around 80% of human diet comes from plants (Collette 2013) agriculture and forest products have major contribution to food availability. From over 30.000 edible plant species, the global calories supply only relies on just 12 domesticated plant species: 8 cereals (barley, maize, millet, rice, rye, sorghum, sugar cane and wheat) and 4 tubers (cassava, potato, sweet potato & yam) (Daudet 2012; Jaenicke & Höschle-Zeledon 2006; Smith 2011). Most of people in rural areas of developing countries, however, use wild plants in their diet. Bharucha and Pretty (2010) estimated that around 300 million people rely on wild food provided by forest ecosystem.

Moringa peregrina is one of plant species that potentially become important in developing countries where hunger and undernourishment is a major concern. Traditionally, young seeds of the plant are eaten in India and the mature one are fried or roasted in Malawi (FAO 1988). Due to its valuable nutrient content and tolerant to severe drought, the plant could become an important future crop in arid and semi arid regions. In this paper, the current status of *M. peregrina* in Saudi Arabia will be reviewed. Along with Yemen and Oman, Saudi Arabia is one of native distribution areas of the tree in the Middle East (Boulos 1999). In the last decades the study on *M. peregrina* in Saudi Arabia has increased, leading to better understanding on its distribution and ecology, nutrient content from various parts of the plant, medicinal properties, threats and conservation status, and conservation action needed for protecting and utilizing the plant sustainably.

II. GENERAL DESCRIPTION OF *M. peregrina*

Moringa peregrina is a member of *Moringaceae* family. It is an extremely fast growing tree with 5-15 m height, diameter of 20-40 cm, and grayish-green bark. It has 20-70 cm leaves with several tiny leaflets that drop when the leaf matures.

The flowers (10-15 mm long) are generally yellowish white to pink, bisexual and harbor insect-pollination characteristics *e.g.* large, showy, slightly scented, and zygomorphic (Täckholm, 1974; Boulos, 1999; Gomaa and Pico, 2011). The flowering season is from March to April and fruiting period last for up to 3 months (Hegazy *et al.*, 2008). The fruit size is 10-25 x 1-1.5 cm and has 5-15 ovoid, trigonous, hard-coated seeds. Hegazy *et al.* (2008) reported that the withering rate of flowering bud ranges between 40 and 50% and fruit set is very low ranging from a low of 0.05 to a high of 0.07%. This low fecundity makes a large *M. peregrina* trees can only produce very low numbers of seeds despite thousands of flowers emerge during the flowering season. Another unique trait of the tree is that the root forms a tuber, which starts to take on form at the seedling phase (Munyanziza and Yongabi, 2007).

III. DISTRIBUTION AND ECOLOGY

In Saudi Arabia, *M. peregrina* is mainly distributed in South and North Hijaz (Migahid, 1978). South Hijaz represents the south part of the western region extending south of Jeddah till Yemen boundaries. North Hijaz is area in the western part of Saudi Arabia that extends alongside the Red Sea coast north of Jeddah. Areas in South Hijaz where the tree can be found include Fayfa Mountains (Alfarhan *et al.* 2005) and Najran-Asir plateau (AGEDI and Hyder, 2013). In the North Hijaz, the tree can be found in Red Sea coast south of Jeddah (Vesey-Fitzgerald 1957), Medina (Osman 2010), Al-Wajh (Osman 2010; Osman and Abohassan 2012), Tabuk (Alatar 2011; Osman and Abohassan 2012) and Al Ula (Al Kahtani and Abou-Arab 1993).

In addition, the tree is also observed in ‘Uruq Bani Ma‘arid, a protected area located along the western edge of the Rub’ al-Khali (Hall *et al.* 2011) (Fig. 1).

It seems that *M. peregrine* is adapted to wide range of environmental conditions. Abulfatih (1991) reported that in southwestern of Saudi Arabia the tree was found in coastal plains area (0-300 m above sea level) and on hillsides of upper escarpment areas (1600-2200 m above sea level) on hard sandy-silty and sandy stony soil, respectively. Hall *et al.* (2011) observed the tree in the incised wadis of the limestone plateau of ‘Uruq Bani Ma‘arid. In Fayfa Mountains, the tree can be found in east facing slopes at elevation of c. 2000 m above sea level together with *Acacia asak* and some succulent shrubs such as *Aloe* spp. and *Euphorbia* spp. (Alfarhan *et al.* 2005). Further detailed study on the ecology and habitat preferences of *M. peregrina* is needed, especially in northern part of the distribution areas where an ecological data is limited. This information will be very important for conservation and further sustainable utilization of the species.

Cossalter (1989) reported that *M. peregrina* is a drought resistant tree which can grow in soils with water table several meter deep. This drought resistant might due to xerophytic characteristics of the tree, which appear when available soil moisture becomes low. Al-Gohary and Hajar (1996) found that Arabian *M. peregrina* shows xerophytic modification in its leaves and stem following water deficit treatment. These modification include reduce surface to volume ratio of leaf and stem, leaf rolling and hair covering, and increased frequencies and indexes of stomata.

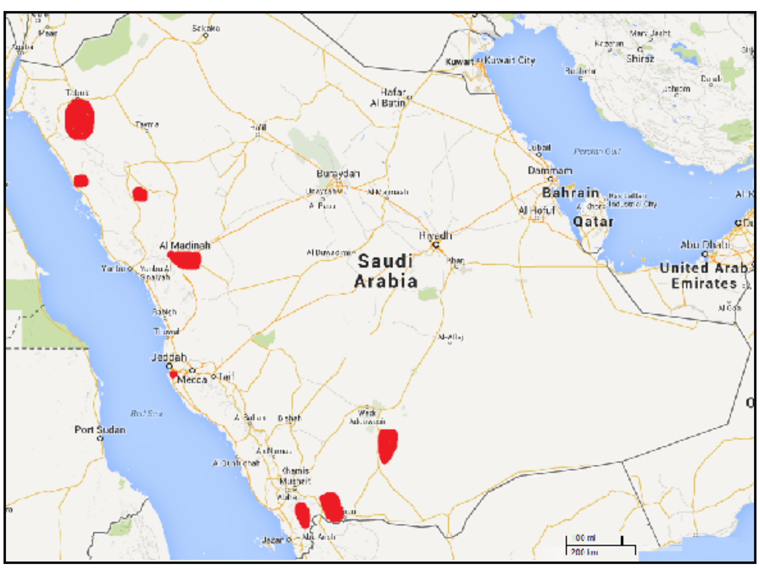

Fig. 1. Distribution of *Moringa peregrina* in Saudi Arabia (red color). Maps from https://maps.google.com/

This drought tolerant was also observed in newly germinated *M. peregrina* as shown by study of Hajar (1997). As water scarcity is the major problem in arid and semi-arid regions, the drought resistant characteristic of *M. peregrina* make this tree very suitable to be planted in these regions.

IV. NUTRIENT CONTENT

The seeds and leaves of *M. peregrina* are known to have valuable nutrients for human diet. In Saudi Arabia, the seeds contain oil that range from 49.8% to 57.25% (Osman and Abohassan 2012; Tsaknis 1998). This oil yield is much higher than of *M. peregrina* seeds from Egypt (42.23%) (Abd El Baky and El-Baroty 2012) and seeds of some common crops like cotton (15.0–24.0%), soybean (17.0–21.0 %) and sunflower (25.0-40.0%) (Pritchard 1991). The oil has very high unsaturated fatty acid (70%) with oleic as the major component (up to 70. 52%). Table 1 shows fatty acids composition of Arabian *M. peregrina* oil and its comparison with the Egyptian seeds, *M. oleifera* and the well-known olive oil. In *M. peregrina* oil, linolenic acid (C18:3) is not detected which make the oil more resistance to oxidation than olive oil. Linolenic acid is known to be more susceptible to oxidation and will make the oil becoming rancid more quickly (Warner and Mounts 1993). The oil also has higher tocopherols which consist of α- β- and δ-tocopherol, at concentrations of 145, 58 and 66 mg/kg, respectively (Tsaknis 1998). This high content of tocopherols will serve as protector for the oil during the storage and processing. Recent study by Lalas *et al.* (2012) showed that *M. peregrina* seed oil could resist up to 10.5 hours at 120 °C, which is much higher than of extra virgin olive oil (8.9 hours). With all these characteristics, oil from *M. peregrina* can be useful for edible purposes and industrial applications.

The seeds of *M. peregrina* have around 18.9% carbohydrate and 23.8% protein (Al Kahtani and Abou-Arab 1993). These values are lower than of *M. oleifera* which have around 21.12% and 33.25% of carbohydrate and protein, respectively (Oliveira *et al.* 1999). In term of amino acid composition, only 17 amino acids are found in the seed of *M. peregrina* where almost all of their values are lower than of *M. oleifera* (Table 2). In both species, the most dominant amino acids are Glutame and Arginine.

Table 1: Composition of Arabian *Moringa peregrina* seed oil compared to of the Egyptian, *M. oleifera* and olive oil.

Fatty acid	Carbons	*Moringa peregrina* (%)		*M. oliefera*[c]	Olive oil (%)[a]
		Saudi Arabia[a]	Egypt[b]		
Capric	C10:0	0.08	not detected		not detected
Myristic	C14:0	0.1	not detected	0.08	<0.01
Palmitic	C16:0	8.9	12.44	5.45	11.2
Palmitoleic	C16:1	not detected	1.54	1.48	0.6
Margaric	C17:0	not detected	not detected	0.08	0.1
Stearic	C18:0	3.82	4.35	5.42	2.8
Oleic	C18:1	70.52	65.36	72.9	72.21
Linoleic	C18:2	0.62	15.32	0.76	4.2
Linolenic	C18:3	not detected	not detected	0.14	0.5
Arachidic	C20:0	1.94	not detected	3.39	0.6
Gadoleic	C20:1	1.5	not detected	2.2	0.2
Behenic	C22:0	2.36	0.98	6.88	<0.01
Erucic	C22:1	0.49	not detected	0.14	not detected

[a]from Tsaknis (1998); [b]from Abd El Baky and El-Baroty (2013); [c]from Foidl *et al.* (2001)

The leaves of *M. peregrina* from Saudi Arabia contain 23.31% proteins, 5.81% fat and 6.39% fiber (Osman and Abohassan 2012). These values are lower than of leaves of *M. oleifera* which have 27.2%, 17.1% and 19.4% of the respective components (Yameogo *et al.* 2011). The low content of fat makes *M. peregrina* leaves as a good source of low fat diet. The leaves are good source of sulfur-containing amino acid cystine as well as other amino acids, although their values are lower than of *M. oleifera* leaves (Table 2). Compared to common cereals and vegetables, the iron (Fe) content of *M. peregrina* leaves is much higher (Table 3).

Table 2: Composition of amino acid (%) in seed and leaf of *Moringa peregrine* and *M. oleifera.*

Amino acid	*Moringa peregrina*[a]		*M. oleifera*[b]	
	Seed	Leaf and stem	Seed	Leaf
Aspartic	4.4	4.2	3.8	8.83
Threonine	5.71	1,63	2.15	4.66
Serine	4.05	1,51	2.64	4.12
Glutame	18.14	4.06	19.46	10.22
Proline	3.71	3.02	5.27	5.43
Glycine	3.62	1.87	4.76	5.47
Alanine	2.05	2.62	3.67	7.32
Cystine	0.34	1,87	4.13	1.35
Valine	2.98	2.95	3.4	5.68
Methionine	1.36	0,36	1.93	1.98
Isoleucine	2.84	4,66	2.99	4.5
Leucine	5.44	4,74	5.11	8.7
Tryosine	1.61	1.63	1.44	3.87
Phenyalanine	3.33	2.75	3.83	6.18
Histidine	3.61	1,55	2.2	2.99
Lysine	2.75	2,91	1.41	5.6
Arginine	10.78	2.67	11.41	6.23

[a]from Osman and Abohassan (2012); [b]from Makkar and Becker (1997)

Table 3: Mineral content (mg/100 g) of various foods[a] for comparison to *Moringa peregrina* leaves.

Food	Ca	Fe	Mg	P	K	Na	Zn	Cu	Mn
M. peregrina leaves[b]	23.9	84.46	5.3	1.9	35	10.9	2.208	0.786	17.79
M. oleifera leaves[c]	19.1	107.48	3.8	30.15	9.7	192.95	60.06	6.1	81.65
Cereals									
Wheat flour, unenriched	15	1.17	22	108	107	2	0.7	0.144	0.682
Bread, wheat	142	3.46	48	155	184	521	1.21	0.159	1.123
Rice, white, unenriched	9	0.8	35	108	86	1	1.16	0.11	1.1
Corn, sweet, white, raw	2	0.52	37	89	270	15	0.45	0.054	0.161
Corn, yellow	7	2.71	127	210	287	35	2.21	0.314	0.485
Vegetables									
Green beans	37	1.04	25	38	209	6	0.24	0.069	0.214
Carrots	33	0.3	12	35	320	69	0.24	0.045	0.143
Spinach	58	0.8	39	28	130	130	0.38	0.093	0.639
Lettuce, green leaf	36	0.86	13	29	194	28	0.18	0.029	0.25
Soybeans, green	197	3.55	65	194	620	15	0.99	0.128	0.547

[a]Obtained from the USDA Natl. Nutrient database for standard references (http://www.nal.usda.gov/fnic/foodcomp/ search/). Nutrient values and weights are for the edible portion; [b]from Osman and Abohassan (2012); [c]from Ogbe and Affiku (2011)

V. MEDICINAL PROPERTIES

There are very little pharmacological investigations conducted using plant material of Arabian *M. peregrina*. To the best of our knowledge, studies by Akbar and Yahya (2011), Lalas *et al.* (2012) and Hajar and Gumgumjee (2014) are the only sources of information. Akbar and Yahya (2011) found that aerial part extracts of Arabian *M. peregrina* contain flavanoid, tannins, sterols/triterpenes and saponins. This extracts have significant effect on stimulating central nervous system activities and antimicrobial activities against *Stapylococcus aureus* and *Bacillus subtilis* with minimal inhibitory concentrations (MIC) of 2 mg/ml each.

Further, Lalas *et al.* (2012) found that the seed oil of *M. peregrina* was active against *S. aureus, S. epidermidis, Pseudomonas aeruginosa, E. cloacae, K. pneumoniae, E. coli, Candida albicans, C. tropicalis* and *C. glabrata*. The MIC for these respective microbes are 3.5, 3.35, 4.38, 4.8, 4.3, 4.95, 5.7, 3.3, and 3.25 mg/ml. Suarez et al. (2003) also observed antimicrobial activities of *M. oleifera* seed oil for *S. aureus* and *E. coli*, however the values are much lower (3.5 and 4.95, respectively). Lastly, recent study by Hajar and Gumgumjee (2014) showed antibacterial and antifungal property of ethanol extract from leaves, seed coat and seed endosperm of *M. peregrina*. Leaves extract was active against *S. aurueus, M. lutues, B.subtilis, K. peneumonia, P. aeruginosa, E. coli* with magnitude of inhibition zones of 27.67, 23.67, 20.00, 26.67, 20.67 and 19.67 mm, respectively. Similar pattern was also observed for seed coat extract. For seed endosperm, its extract was only active against *M. lutues, E. coli*, and *K. peneumonia* with inhibition zones of 13.33, 17.67 and 16.33 mm, respectively. These inhibitory activities of all extracts were higher compared to the standard antibiotics such as ciproflaxocin and streptomycin. The authors were also explored the antimicrobial effect of *M. peregrina* leaves extract on *S. aurueus* and *C. albicans* at the molecular level using random amplification of polymorphic DNA (RAPD). The results demonstrated polymorphic band pattern for most the treated microbes compared with the untreated strains, which may indicate molecular changes induced by leaves extract. Medicinal properties of *M. peregrina* have also been examined for the populations located in Iran (Afsharypuor *et al.* 2010; Dehshahri *et al.* 2012a; Dehshahri *et al.* 2012b) and Egypt (Abd El Baky and El-Baroty, 2012; Abdel-Rahman *et al.* 2010; Koheil *et al.* 2011; El-Alfy *et al.* 2011; Elbatran *et al.* 2005). These studies revealed several compounds isolated from various parts of *M. peregrina* and their medical importance. Table 4 summarizes the name of the compounds, theirs sources and activities.

Table 4: Compounds extracted from *Moringa peregrina* and their biological activities.

Compound	Source	Activities	Reference
6,8,3,5-Tetramethoxy Apigenin	Aerial part	Anti-inflammatory, analgesic activities and inhibiting the development of gastric lesion in rats	Elbatran *et al.* (2005)
6-methoxy-acacetin-8-C-β-glucoside	Aerial part	Cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	El-Alfy *et al.* (2011)
Apigenin	Aerial part	Antibacterial, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Abdel-Rahman *et al.* (2010); El-Alfy *et al.* (2011)
Chrysoeriol-7-0-rhamnoside	Aerial part	Anti-inflammatory, analgesic activities, inhibited the development of gastric lesion in rats, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Elbatran *et al.* (2005); El-Alfy et al. (2011)
Isothiocyanates	Seed coat, seed kernel, leaves and stem	Anti oxidative, anti bacterial, anti cancer and chemoprotective properties	Afsharypuor et al. (2010); Dehshahri et al. (2012a)
Lupeol acetate	Aerial part	Antibacterial, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Abdel-Rahman *et al.* (2010); El-Alfy *et al.* (2011)
Neochlorogenic acid	Aerial part	Cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	El-Alfy *et al.* (2011)
Quercetin	Aerial part	Anti-inflammatory, analgesic activities, inhibited the development of gastric lesion in rats, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Elbatran *et al.* (2005); El-Alfy *et al.* (2011)
Quercetin-3-0-rutinoside (rutin)	Aerial part; leaves	Anti-inflammatory, analgesic activities, inhibited the development of gastric lesion in rats, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect, antioxidant	Elbatran et al. (2005); El-Alfy *et al.* (2011); Dehshahri *et al.* (2012b)
Rhamnetin	Aerial part	Cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, antihyperglycemic effect	El-Alfy *et al.* (2011)

Table 4: Cont..

Compound	Source	Activities	Reference
Rhamnetin-3-O-rutinoside	Aerial part	Cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	El-Alfy *et al.* (2011)
Sitosterol	Aerial part	Antibacterial, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Abdel-Rahman *et al.* (2010); El-Alfy *et al.* (2011)
Sitosterol-3-O-D-glucoside	Aerial part	Antibacterial, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Abdel-Rahman *et al.* (2010); El-Alfy *et al.* (2011)
Total phenolic	Leaves	Antioxidant	Dehshahri *et al.* (2012b)
Unknown (aerial part extracts)	Aerial part	Stimulating central nervous system activities and antimicrobial activities	Akbar and Yahya (2011)
Unknown (seed extracts)	Seed	Anti-inflammatory and antioxidant agent	Koheil *et al.* (2011)
Unknown (seed oil)	Seed	Antibacterial, inhibiting the growth of breast adenocarcinoma cells (MCF-7), hepatocellular carcinoma (HepG2) and colon carcinoma (HCT-116), anti-oxidant activity	Lalas et al. (2012); Abd El Baky and El-Baroty (2012)
α-Amyrin	Aerial part	Antibacterial, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Abdel-Rahman *et al.* (2010); El-Alfy *et al.* (2011)
β-Amyrin	Aerial part	Antibacterial, cytotoxic activities against breast (MCF 7) and colon (HCT 116) cancer cell lines, anti hyperglycemic effect	Abdel-Rahman *et al*. (2010); El-Alfy *et al.* (2011)

VI. PHENOTYPIC AND GENETIC VARIATION

Genetic variation will provide good opportunities for improvement of *M. peregrina*. Such information, however, is not available for the Arabian populations. The only variations were observed for height and stem diameter in North West region of the country (Osman and Abohassan, 2012). Thus, further detailed study on morphological and genetic variation of Arabian *M. peregrina* is urgently needed to provide sufficient information for facilitating tree improvement programs and the conservation and exploitation of *M. peregrina* genetic resources.

VII. CONSERVATION STATUS

The conservation status of Arabian *M. peregrina* is unknown due to absent of study assessing the population size and structure, population trend, occurrence and occupancy areas, and treats associated with the species. In general, the species has also not been assessed for the IUCN Red List. Populations in Egypt, however, are reported to experience rapid decrease mainly due to over-harvesting for fuel and medicinal uses, over-grazing by animal and habitat destruction by unmanaged human activities (Abd El-Wahab *et al.* 2004). The same population decrease may already happen to the Arabian populations as human populations is steadily increasing, which in turn may affect the natural ecosystems of the country.

VIII. CONCLUSION

M. peregrina is a promising candidate for future crop, especially in arid regions where hunger and undernourished prevalence is high. In Saudi Arabia, studies have shown that the tree contains very valuable nutrient and medicinal properties. Further researches on population ecology and genetic variation are very important to help protecting this valuable tree in Saudi Arabia.

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