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Moringa (*Moringa oleifera* Lam.): potential uses in agriculture, industry and medicine

Moringa (*Moringa oleifera* Lam.): usos potenciales en la agricultura, industria y medicina

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Abstract

The aim of this review was to analyze the scientific information on *Moringa oleifera* Lam. in terms of its distribution, chemical composition and characterization, which allows backing up its medicinal, agricultural, livestock and industrial uses. The moringa is a tree native to India and introduced into the Americas. Its growth habitat is tropical (< 2000 masl). Proteins, fiber, carbohydrates, amino acids, vitamins, minerals and secondary metabolites (carotenoids and tocopherols) have been quantified in the plant, which partly explains its uses as food, a disease treatment (respiratory, gastrointestinal, inflammatory, cardiac, nutritional and skin ailments), a soil improver, raw material for the food and cosmetics industries and for the treatment of contaminated water. The results allowed identifying the attributes and applications of moringa, as well as the need for specific studies to enhance its production and application technology for the benefit of the consumer.

Keywords: medicinal plant, food, fodder, agro-industrial uses.

Resumen

El objetivo de esta revisión fue analizar información científica de *Moringa oleifera* Lam. sobre su distribución, composición química y caracterización, que permite sustentar sus usos medicinales, agrícolas, pecuarios e industriales. La moringa es un árbol nativo de la India e introducido a América. Su hábitat de crecimiento es el trópico (< 2000 msnm). En la planta se han cuantificado proteínas, fibra, carbohidratos, aminoácidos, vitaminas, minerales y metabolitos secundarios (carotenos y tocoferoles); lo que explica parcialmente sus usos como alimento, tratamiento de enfermedades (respiratorias, gastrointestinales, inflamatorias, cardiacas, nutricionales y cutáneas), mejorador de suelo, materia prima para la industria alimentaria y de cosméticos y para el tratamiento de agua contaminada. Los resultados permitieron identificar los atributos y aplicaciones de moringa; así como la necesidad de realizar estudios específicos para potenciar su producción y aplicación tecnológica en beneficio del consumidor.

Palabras clave: planta medicinal, alimenticia, forrajera, usos agroindustriales.

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Introduction

Moringa oleifera Lam. is native to the Himalayas (Sanjay & Dwivedi, 2015). As an edible species it was introduced into the Americas in the nineteenth century (Falasca & Bernabé, 2008), or perhaps in colonial times from the Philippines by seamen crewing the so-called *Nao de China* route between Manila and Acapulco (Olson & Fahey, 2011). It is one of the 13 identified species of the family *Moringaceae*, belonging to the genus *Moringa*. It is identified by its pinnate leaves and long, woody pod, which when mature opens into three valves which contain the seeds with three wings (Olson & Fahey, 2011). This plant is consumed as food for its nutritional value, and according to Ayurvedic medicine (Singh, 2012a) it is attributed with properties for the treatment of certain ailments such as asthma, epilepsy, eye and skin diseases, fever and hemorrhoids (Sanjay & Dwivedy, 2015). The seed is used to treat river water with suspended solids and groundwater (Aziz, Jayasuriya, & Fan, 2015; Lijesh & Malhotra, 2016; Sasikala & Muthurama, 2015), and as a source of oil for biodiesel production (Mofijur et al., 2014; Rahman et al., 2014; Sharma, Rashid, Anwar, & Erhan, 2009).

In moringa, proteins, fiber, carbohydrates, amino acids, vitamins, minerals (Amaglo et al., 2010; Asiedu-Gyekye, Frimpong-Manso, Awortwe, Antwi, & Nyarko, 2014), secondary metabolites (carotenes and tocopherols) (Amaglo et al., 2010; Cheehpracha et al., 2010) and some minor metabolites (Föster, Ulrich, Schreiner, Müller, & Mewis, 2015) have been identified; this indicates that it can be raw material for the food, balanced animal feed and cosmetics industries (Aney, Rashmi, Maushumi, & Kiran, 2009).

Therefore, the aim of this review was to analyze the scientific information on *Moringa oleifera* Lam. in terms of its distribution, botanical and agronomic characterization, chemical composition, pharmacological characteristics and medicinal, agro-industrial, biofuel and water treatment uses, which allow supporting the various properties attributed to it.

Taxonomy and botanical characteristics

Moringa oleifera (Familia *Moringaceae*) is one of 13 species of the genus *Moringa*. It is identified by the fruit in the form of a long, woody pod, which when mature opens into three valves and contains tri-valve seeds with longitudinal wings. Its pinnate leaves are divided into leaflets arranged on a rachis. The flowers are zygomorphic with five petals, five sepals, five functional stamens and several staminodes; they have pedicels and axillary inflorescences. The plant has erect stems and tuberous roots (Olson, 2010; Olson & Fahey, 2011). The tree can reach up to 10 m in height (Paliwal, Sharma, & Pracheta, 2011).

Introducción

Moringa oleifera Lam. es originaria de la zona de los Himalayas (Sanjay & Dwivedi, 2015). Como especie comestible se introdujo a América durante el siglo XIX (Falasca & Bernabé, 2008), o quizá en la época colonial desde Filipinas por los tripulantes de la Nao de China (Olson & Fahey, 2011). Es una de las 13 especies identificadas de la familia *Moringaceae*, perteneciente al género *Moringa*. Se identifica por sus hojas pinnadas y su vaina larga y leñosa, que al madurar se abre en tres valvas, la cual contienen las semillas con tres alas (Olson & Fahey, 2011). Esta planta se consume como alimento por su valor nutricional, y de acuerdo con la medicina ayurvédica (Singh, 2012a) se le atribuyen propiedades para el tratamiento de algunos padecimientos como asma, epilepsia, enfermedades de los ojos y de la piel, fiebre y hemorroides (Sanjay & Dwivedy, 2015). La semilla se usa para tratamiento de agua de río con sólidos suspendidos y aguas subterráneas (Aziz, Jayasuriya, & Fan, 2015; Lijesh & Malhotra, 2016; Sasikala & Muthurama, 2015), y como fuente de aceite para la producción de biodiesel (Mofijur et al., 2014; Rahman et al., 2014; Sharma, Rashid, Anwar, & Erhan, 2009).

En moringa se han identificado proteínas, fibra, carbohidratos, aminoácidos, vitaminas, minerales (Amaglo et al., 2010; Asiedu-Gyekye, Frimpong-Manso, Awortwe, Antwi, & Nyarko, 2014), metabolitos secundarios (carotenos y tocoferoles) (Amaglo et al., 2010; Cheehpracha et al., 2010) y algunos metabolitos minoritarios (Föster, Ulrich, Schreiner, Müller, & Mewis, 2015); esto indica que puede ser materia prima para la industria alimentaria, de alimentos balanceados para animales y de cosméticos (Aney, Rashmi, Maushumi, & Kiran, 2009).

Por lo anterior, el objetivo de esta revisión fue analizar la información científica de *Moringa oleifera* Lam. sobre su distribución, caracterización botánica y agronómica, composición química, estudios farmacológicos y usos medicinales, agroindustriales, forrajeros, en biocombustible y tratamiento de agua, que permiten soportar las diversas propiedades que se le atribuyen.

Taxonomía y características botánicas

Moringa oleifera (Familia *Moringaceae*) es una de las 13 especies del género *Moringa*. Se identifica por el fruto en forma de vaina larga y leñosa, que al madurar se abre en tres valvas, y contiene las semillas trivalvas con alas longitudinales. Sus hojas pinnadas están divididas en folíolos dispuestos sobre un raquis. Las flores son zigomórficas con cinco pétalos, cinco sépalos, cinco estambres funcionales y varios estaminodios; tienen pedicelos e inflorescencias axilares. La planta posee tallos erectos y raíces tuberosas (Olson, 2010; Olson & Fahey, 2011). Es un árbol que puede alcanzar hasta 10 m de altura (Paliwal, Sharma, & Pracheta, 2011).

Geographic origin and distribution

Moringa oleifera is originally from the Himalayas (Kumar, 2013; Sanjay & Dwivedi, 2015), and is native to India, Pakistan, Bangladesh and Afghanistan (Fahey, 2005). Its distribution has spread to Southeast Asia, Western Asia, the Arabian Peninsula, East and West Africa and islands in the Indian and Pacific oceans. In the Americas it is found from southern Florida (USA) to Argentina, and on the islands of the Caribbean and West Indies (Olson, 2010; Paliwal et al., 2011). In Mexico it is found on the Pacific coast from Baja California and Sonora to Chiapas (Olson & Fahey, 2011). Recently, Olson and Fahey (2011) reported the introduction of this plant into the Americas, as an edible species, from the Philippines by the crews of the *Nao de China*; however, Falasca and Bernabé (2008) argue that it arrived during the nineteenth century.

Agronomic characteristics

M. oleifera grows in tropical areas (in low-altitude places, < 2000 masl) and in different types of soil (clayey and sandy), except in poorly-drained ones. It is a plant that tolerates drought conditions, but water stress (minimum annual rainfall of 250 mm) affects its growth (Dubey, Dora, Kumar, & Gulsan, 2013). It is propagated by seed and stake (Nouman et al, 2014.); peeling is not necessary for the seeds to germinate (Padilla, Fraga, & Suárez, 2012).

Due to its composition and climatic conditions, the plant is affected by various pests (ants, zoompopos and *Fusarium* species) (Padilla et al., 2012). On the other hand, the application of nitrogen fertilizers to the plant increases its biomass production (Mendieta, Spörndly, Reyes, Salmerón, & Halling, 2012), and biofertilizers improve its ability to metabolize nutrients and increase its growth (Zayed, 2012).

The geographical area and growing season influence the synthesis and concentration of metabolites due to soil type, climate, fertilization and water availability (Iqbal & Bhager, 2006; Anwar & Rashid, 2007; Melesse, Steingass, Boguhn, Schollenberger, & Rodehutscord, 2012; Dubey et al., 2013; Föster et al., 2015). In this regard, further studies need to be conducted to generate production technology for moringa, where agronomic management and evaluation of the quality of the product (leaf, stem, root and seed) are included.

Chemical composition

Nutritional

In Asia, the leaf, fresh pod (fruit) and seed of *M. oleifera* are consumed, and the root is used as a condiment (Omotesho et al., 2013). Table 1 shows the nutritional

Origen y distribución geográfica

Moringa oleifera es originaria de la zona de los Himalayas (Kumar, 2013; Sanjay & Dwivedi, 2015), y nativa de la India, Paquistán, Bangladesh y Afganistán (Fahey, 2005). Su distribución se ha extendido al sureste de Asia, Asia occidental, Península Arábiga, este y oeste de África e islas del Océano Índico y Pacífico. En América se le encuentra desde el sur de Florida (Estados Unidos de América) hasta Argentina, y en las islas del Caribe y las Indias occidentales (Olson, 2010; Paliwal et al., 2011). En México se encuentra en la costa del Pacífico, desde Baja California y Sonora hasta Chiapas (Olson & Fahey, 2011). Recientemente, Olson y Fahey (2011) reportan la introducción de esta planta en América, como especie comestible, desde Filipinas por los tripulantes de la Nao de China; sin embargo, Falasca y Bernabé (2008) señalan que su llegada fue durante el siglo XIX.

Características agronómicas

M. oleifera crece en zonas tropicales (en lugares con baja altitud, < 2000 msnm) y en diferentes tipos de suelos (arcillosos y arenosos), excepto en los mal drenados. Es una planta que tolera condiciones de sequía, pero el estrés hídrico (precipitación pluvial mínima anual de 250 mm) afecta su crecimiento (Dubey, Dora, Kumar, & Gulsan, 2013). Se propaga por semilla y estaca (Nouman et al., 2014); no es necesario remover la cáscara de las semillas para su germinación (Padilla, Fraga, & Suárez, 2012).

Debido a su composición y condiciones climáticas, la planta es afectada por diversas plagas (hormigas, zoompopos y especies de *Fusarium*) (Padilla et al., 2012). Por otra parte, la aplicación de fertilizantes nitrogenados a la planta aumenta su producción de biomasa (Mendieta, Spörndly, Reyes, Salmerón, & Halling, 2012), y con biofertilizantes mejora su habilidad de metabolizar nutrimentos e incrementar su crecimiento (Zayed, 2012).

La zona geográfica y la época de cultivo influyen en la síntesis y concentración de metabolitos debido al tipo de suelo, clima, fertilización y disponibilidad de agua (Iqbal & Bhager, 2006; Anwar & Rashid, 2007; Melesse, Steingass, Boguhn, Schollenberger, & Rodehutscord, 2012; Dubey et al., 2013; Föster et al., 2015). Al respecto, es necesario realizar estudios que permitan generar la tecnología de producción para moringa, donde se incluyan manejo agronómico y evaluación de la calidad del producto: hoja, tallo, raíz y semilla.

Composición química

Nutricional

En Oriente, de *M. oleifera* se consume la hoja, vaina fresca (fruto) y semilla, y la raíz se usa como condimento (Omotesho et al., 2013). En el Cuadro 1 se enlista el

Table 1. Nutritional content of the parts of *Moringa oleifera* Lam.
Cuadro 1. Contenido nutricional de las partes de *Moringa oleifera* Lam.

	Leaf f[2] / Hoja f[2]	Leaf d[2] / Hoja d[2]	Leaf d[4] / Hoja d[4]	Leaf d[1] / Hoja d[1]	Leaf d[3] / Hoja d[3]	Seed husk[1] / Cáscara semilla[1]	Seed p[1] / Semilla s/c[1]	Wings[1] / Alas[1]	Stem[4] / Tallo[4]	Pod[2] / Vaina[2]
Moisture % / Humedad %	75.00	7.50	79.20	--	--	--	--	--	--	86.90
Calories in 100 g / Calorías en 100 g	92.00	205.00	--	--	--	--	--	--	--	26.00
Protein (g) / Proteína (g)	0.07	0.27	--	0.26	0.44	0.10	0.37	0.07	0.06	0.03
Fat (g) / Grasa (g)	0.02	0.02	--	nd	0.01	0.02	0.42	nd	nd	0.00
Carbohydrates (g) / Carbohidratos (g)	0.13	0.38	--	--	--	--	--	--	--	0.04
Fiber (g) / Fibra (g)	0.01	0.19	--	--	--	--	--	--	--	0.05
Ash (mg·g^{-1}) / Cenizas (mg·g^{-1})	--	--	--	0.09	0.10	0.02	0.03	0.09	0.07	--
Minerals (g) / Minerales (g)	0.02	--	--	--	--	--	--	--	--	0.02
Total phenols (mg·g^{-1}) / Fenoles totales (mg·g^{-1})	--	--	--	--	34.00	--	--	--	--	--
Tannins (mg·g^{-1}) / Taninos (mg·g^{-1})	--	--	--	--	14.00	--	--	--	--	--
Saponinas (mg·g^{-1}) / Saponins (mg·g^{-1})	--	--	--	--	50.00	--	--	--	--	--
Phytates (mg·g-1) / Fitatos (mg·g^{-1})	--	--	--	--	31.00	--	--	--	--	--
Raw energy (MJ·kg^{-1}) / Energía cruda (MJ·kg^{-1})	--	--	--	19.35	17.70	21.62	26.68	18.52	18.95	--
Carotene (vit. A) (mg) / Caroteno (vit. A) (mg)	0.07	0.19	1.93	--	--	--	--	--	--	--
β-carotene (mg) / β-caroteno (mg)	--		0.93	--	--	--	--	--	--	--
Thiamine (B1) (mg) / Tiamina (B1) (mg)	0.00	0.00	--	--	--	--	--	--	--	--
Riboflavin (B2) (mg) / Riboflavina (B2) (mg)	0.00	0.21	--	--	--	--	--	--	--	--
Niacin (B3) (mg) / Niacina (B3) (mg)	0.01	0.08	--	--	--	--	--	--	--	--
Vitamin C (mg) / Vitamina C (mg)	2.20	0.17	--	--	--	--	--	--	--	--
Ascorbic acid (mg) / Ac. ascórbico (mg)	--	--	6.60	--	--	--	--	--	--	--

nd = not detected; d = dehydrated; f = fresh; p = peeled; ext = extracted
[1]Abbas (2013); [2]Dhakar et al. (2011); [3]Makkar and Becker (1996); [4]Nambiar and Seshadri (2001)

nd = no detectado; d = deshidratado; f = fresco; s/c = sin cáscara; ext = extraído
[1]Abbas (2013); [2]Dhakar et al. (2011); [3]Makkar y Becker (1996); [4]Nambiar y Seshadri (2001)

Table 2. Elements in different parts of *Moringa oleifera* Lam.
Cuadro 2. Elementos en diferentes partes de *Moringa oleifera* Lam.

Element/Elemento	Leaf f[4]/ Hoja f[4]	Leaf d[4]/ Hoja d[4]	Leaf d[6]/ Hoja d[6]	Leaf d[3]/ Hoja d[3]	Leaf d[5]/ Hoja d[5]	Pod[4]/ Vaina[4]	Pod p.j.[2]/ Vaina p.i.[2]	Pod[2]/ Vaina[2]	Flower[2]/ Flor[2]	Petioles f.p.[2]/ Peciolos p.f.[2]	Seed w/h[2]/ Semilla c/c[2]	Seed p[2]/ Semilla s.c.[2]	Seed[1]/ Semilla[1]	Stem[2]/ Tallo[2]	Stem f.p.[2]/ Tallo p.f.[2]	Root[2]/ Raíz[2]
Calcium/Calcio	4.400	20.03	22.40	-	0.019	0.300	0.100	0.180	0.170	0.270	0.720	0.120	0.143	0.340	0.180	0.300
Manganese/Manganeso	0.420	3.680	-	-	0.062	0.240	-	-	-	-	1.700	0.290	3.00×10^{-3}	-	-	-
Phosphorous/Fósforo	0.700	2.040	6.300	-	2.500	1.100	-	-	-	-	-	-	-	-	-	-
Potassium /Potasio	2.590	13.24	-	-	17.70	0.240	2.740	4.450	3.510	2.510	1.710	1.100	2.550	4.420	1.970	2.050
Copper/Cobre	0.007	0.006	-	0.032	0.009	0.031	-	-	-	-	-	-	1.23×10^{-3}	-	-	-
Iron/Hierro	0.009	0.282	0.260	-	0.226	0.053	-	-	-	-	-	-	1.11×10^{-2}	-	-	-
Sulfur/Sulfuro	1.370	8.700	-	-	-	1.370	-	-	-	-	-	-	-	-	-	-
Selenium/Selenio	-	-	-	-	0.027	-	-	-	-	-	0.000	-	4.97×10^{-4}	-	-	-
Sodium/Sodio	-	-	-	-	1.620	-	0.290	0.860	< 0.1	< 0.1	1.410	0.940	1.340	0.480	-	< 0.1
Lithium/Litio	-	-	-	-	-	-	-	-	-	-	-	-	6.62×10^{-6}	-	-	-
Magnesium/Magnesio	-	-	-	-	4.340	-	-	-	-	-	-	-	1.500	-	-	-
Chrome/Cromo	-	-	-	0.578	< 0.005	-	-	-	-	-	-	-	2.65×10^{-4}	-	-	-
Nickel/Níquel	-	-	-	-	-	-	-	-	-	-	-	-	0.25×10^{-4}	-	-	-
Zinc	0.002	0.033	-	0.116	< 0.005	-	-	-	-	-	-	-	1.10×10^{-2}	-	-	-
Rubidium/Rubidio	-	-	-	0.076	-	-	-	-	-	-	-	-	5.43×10^{-4}	-	-	-
Strontium/Estroncio	-	-	-	-	-	-	-	-	-	-	-	-	1.53×10^{-3}	-	-	-
Lead/Plomo	-	-	-	0.004	-	-	-	-	-	-	-	-	0.06×10^{-5}	-	-	-
Thorium/Torio	-	-	-	0.003	-	-	-	-	-	-	-	-		-	-	-
Barium/Bario	-	-	-	0.890	-	-	-	-	-	-	-	-	3.59×10^{-4}	-	-	-

f = fresh; d = dehydrated; f.p. = flowering plant; i.p. = immature plant; w/h = with husk; p. = peeled
Data are expressed in $mg \cdot g^{-1}$.
[1]Al-anizi, Hellyer, and Zhang (2014); [2]Amaglo et al. (2010); [3]Asiedu-Gyekye et al. (2014); [4]Dhakar et al. (2011); [5]Freiberger et al. (1998); [6]Nambiar and Seshadri (2001)

f = fresca; d = deshidratada; p.f. = planta floreando; p.i. = planta inmadura; c/c = con cáscara; s.c. = sin cáscara
Los datos están expresados en $mg \cdot g^{-1}$.
[1]Al-anizi, Hellyer, y Zhang (2014); [2]Amaglo et al. (2010); [3]Asiedu-Gyekye et al. (2014); [4]Dhakar et al. (2011); [5]Freiberger et al. (1998); [6]Nambiar y Seshadri (2001)

Table 3. Amino acid content in parts of *Moringa oleifera* Lam.
Cuadro 3. Contenido de aminoácidos en partes de *Moringa oleifera* Lam.

Amino acid / Aminoácido	Leaf d[3] / Hoja d[3]	Leaf d[2] / Hoja d[2]	Leaf f[1] / Hoja f[1]	Leaf d[1] / Hoja d[1]	Pod f[1] / Vaina f[1]
Aspartic / Aspartato	10.6	12.8	–	–	–
Glutamic / Glutamato	11.69	20.9	–	–	–
Serine / Serina	4.78	7.19	–	–	–
Glycine / Glicina	6.12	8.38	–	–	–
Histidine / Histidina	3.12	3.78	1.498	6.13	1.1
Arginine / Arginina	6.96	14.5	4.066	13.25	3.6
Threonine / Treonina	5.05	7.09	1.177	11.88	3.9
Alanine / Alanina	6.59	11	–	–	–
Proline / Prolina	5.92	10.2	–	–	–
Tyrosine / Tirosina	4.34	8.33	–	–	–
Valine / Valina	6.34	10.8	3.745	10.63	5.4
Methionine / Metionina	2.06	2.34	1.177	3.5	1.4
Isoleusine / Isoleucina	5.18	7.82	2.996	8.25	4.4
Leusin / Leucina	9.86	15.5	4.922	19.5	6.5
Phenylalanine / Fenilalanina	6.24	10.5	3.103	13.88	0.4
Lysine / Lisina	6.61	9.17	3.424	13.25	1.5
Cysteine / Cisteina	1.19	3.87	–	–	–
Tryptophan / Triptofano	2.13	7.53	1.07	4.25	0.8

d = dehydrated; f = fresh
Data are expressed in $mg \cdot g^{-1}$.
[1]Dhakar et al. (2011); [2]Freiberger et al. (1998); [3]Makkar and Becker (1996);

d = deshidratado; f = fresco
Los datos están expresados en $mg \cdot g^{-1}$.
[1]Dhakar et al. (2011); [2]Freiberger et al. (1998); [3]Makkar y Becker (1996);

content with variations attributable to the collection areas. Proteins, fiber, carbohydrates, amino acids, vitamins, carotenes, tocopherols and minerals (Tables 2 and 3) have been identified in the plant, and, as can be seen, the most abundant element is potassium (Abbas, 2013; Abdull, Ibrahim, & Kntayya, 2014; Amaglo et al., 2010; Asiedu-Gyekye et al., 2014; Ayerza, 2012; Dhakar et al., 2011; Sanjay & Dwivedy, 2015; Yameogo, Bengaly, Savadogo, Nikiema, & Traore, 2011). The oil obtained from the seeds is nutritionally valuable and suitable for frying due to its stability and high oleic acid content. In the leaf, linoleic acid is the most abundant acid, while in the rest of the plant it is palmitic acid (Table 4) (Sabo-Mohamed, Long, Lai, Syed-Muhammad, & Mohd-Ghazali, 2007) and omega 3 and 6 acids (Ayerza, 2012). Mmoringa has been recommended by the United Nations (UN) to supplement the human diet (Ashworth & Ferguson, 2008). Some studies show that intake is safe at up to 1 $g \cdot kg^{-1}$ b. wt. (Asare et al., 2012).

Phytochemical

In various parts of the plant, secondary metabolites have been identified: tannins, saponins, polyphenols (flavonoids such as kaempferol, quercetin, myricetin, isorhamnetin, kaempferol glucosides, quercetin and rutinosides),

contenido nutricional con las variaciones atribuibles a las zonas de colecta. En la planta se han identificado proteínas, fibra, carbohidratos, aminoácidos, vitaminas, carotenos, tocoferoles y minerales (Cuadros 2 y 3), y como se puede observar, el elemento más abundante es el potasio (Abbas, 2013; Abdull, Ibrahim, & Kntayya, 2014; Amaglo et al., 2010; Asiedu-Gyekye et al., 2014; Ayerza, 2012; Dhakar et al., 2011; Sanjay & Dwivedy, 2015; Yameogo, Bengaly, Savadogo, Nikiema, & Traore, 2011). El aceite que se obtiene de las semillas es nutritivamente valioso y apto para freír debido a su estabilidad y alto contenido de ácido oleico. En la hoja, el ácido linoleico es el más abundante; mientras que en el resto de la planta el predominante es el palmítico (Cuadro 4) (Sabo-Mohamed, Long, Lai, Syed-Muhammad, & Mohd-Ghazali, 2007) y aceites omega 3 y 6 (Ayerza, 2012). La moringa ha sido recomendada por la Organización de las Naciones Unidas (ONU) para complementar la dieta (Ashworth & Ferguson, 2008). Algunos estudios muestran que es segura su ingesta de hasta 1 $g \cdot kg^{-1}$ corporal (Asare et al., 2012).

Fitoquímica

En diversas partes de la planta se han identificado metabolitos secundarios: taninos, saponinas, polifenoles

Table 4. Fatty acid contents in different parts of *Moringa oleifera* Lam.
Cuadro 4. Contenido de ácidos grasos en diferentes partes de *Moringa oleifera* Lam.

Fatty acids / Ácidos grasos		Oil[1] / Aceite[1]	Root[2] / Raíz[2]	Root f.p.[2] / Raíz p.f.[2]	Stem[2] / Tallo[2]	Stem f.p.[2] / Tallo p.f.[2]	Petioles f.p.[2] / Peciolos p.f.[2]	Leaf[2] / Hoja[2]	Leaf f.p.[2] / Hoja p.f.[2]	Flower[2] / Flor[2]	Pod g[2] / Vaina v[2]	Pod m[2] / Vaina m[2]	Seed w/h[2] / Semilla c/c[2]	Seed p[2] / Semilla s/c[2]
Myristic acid / Ác. mirístico	$C_{14:0}$	-	0.46	0.42	0.6	0.62	0.66	0.13	0.14	0.16	0.34	0.1	0.07	0.11
Palmitic acid / Ác. palmítico	$C_{16:0}$	6.45	39.4	41.3	47.8	47.1	37.3	26	25.3	33.6	48	9.16	8.4	9.05
Palmitoleic acid / Ác. palmitóleico	$C_{16:1}$	0.97	0.53	1.68	0.37	1.35	0.63	0.56	0.55	0.22	0.97	1.44	1.91	2.27
Heptadecanoic acid / Ác. heptadecanoico	$C_{17:0}$	-	1.3	1.2	0.96	1.45	1.46	0.46	0.25	0.41	0.97	0.1	0.09	0.09
Heptadecenoic acid / Ác. heptadecenoico	$C_{17:1}$	-	0.03	0.12	0	0	0	0	0	0.28	0	0.03	0.01	0.06
Stearic acid / Ác. esteárico	$C_{18:0}$	5.5	7.38	6.03	11.5	9,21	4.79	4.33	3.02	5.54	13.4	5.32	9.92	4.26
Oleic acid / Ác. oleico	$C_{18:1}$	± 0.5	30.6	37	16.4	18.6	17.3	14	6.81	29	34.6	78.9	74.5	80.6
Linolenic acid / Ác. linoleico	$C_{18:2}$	1.27	10.8	9.58	16.5	15.9	21.4	15.9	11.4	18.6	0.02	1.16	0.69	0.66
Linolenic acid / Ác. linolénico	$C_{18:3}$	0.3	2.26	1.42	4	3.9	16.2	37.3	50.8	10.6	0.02	0.5	0.23	0.16
Arachidic acid / Ác. araquídico	$C_{20:0}$	4.08	5.02	0.92	1.87	1.67	0.11	0.11	1.27	1.23	1.54	3.02	3.86	2.58
Eicosenoic acid / Ác. eicosenoico	$C_{20:1}$	1.68	2.21	0.3	0.04	0.05	0.05	0.05	0.11	0.33	0.03	0.17	0.33	0.17
Behenic acid / Ác. behenico	$C_{22:0}$	6.16	0.02	0.01	0.04	0.05	0.05	0.05	0.01	0.01	0.03	0.03	0.01	0
Lignoceric acid / Ác. lignocérico	$C_{24:0}$	0.02	0.02	0.1	0	0.05	0.03	0.03	0.01	0.01	0.03	0.03	0.01	0

f.p.. = flowering plant; i.p. = immature plant; w/h = with husk; p. = peeled; g = green; m = mature.
Data expressed in g·100 g^{-1}.
[1]Freiberger et al. (1998); [2]Nambiar and Seshadri (2001).

p.f. = planta floreando; p.i. = planta inmadura; c/c = con cáscara; s/c = sin cáscara; v = verde; m = madura.
Los datos están expresados en g·100 g^{-1}.
[1]Freiberger et al. (1998); [2]Nambiar and Seshadri (2001).

malonilglucosides, phenolic glucosides (niazirin and niacin), cardiac glucosides, isocyanates, sterols and glucosterols, fatty acids and alkaloids (Alhakmani, Kumar, & Khan, 2013; Amaglo et al., 2010; Borges-Teixeira, Barbieri-Carvalho, Neves, Apareci-Silva, & Arantes-Pereira, 2014; Cheehpracha et al., 2010; Maguro & Lemmen, 2007). In addition, minor metabolites such as glucosinolates [4-(α-L-rhamnopyranosyloxy)-benzyliglucosinolate], isocyanates[pterigospermin,(4-(α-L-rhamnosyloxy)-benzyl isothiocyanate],1[4(4'-0-acetyl-α-L-rhamnosyloxy)-benzyl isothiocyanate], dipeptides (aurantiamide acetate) and urea derivatives (1,3-dibenzylurea) have been described (Föster et al., 2015; Howarth & Benin, 2011; Sashidhara et al., 2009; Waterman et al., 2014). In Table 5, substances contained in different parts of the plant are listed.

(flavonoides tales como campferol, quercetina, mirecetina, isoramnetina, glucósidos de campferol, quercetina y rutinósidos), malonilglucósidos, glucósidos fenólicos (niazirina y niazicina), glucósidos cardiacos, isocianatos, esteroles y glucoesteroles, ácidos grasos y alcaloides (Alhakmani, Kumar, & Khan, 2013; Amaglo et al., 2010; Borges-Teixeira, Barbieri-Carvalho, Neves, Apareci-Silva, & Arantes-Pereira, 2014; Cheehpracha et al., 2010; Maguro & Lemmen, 2007). Asimismo, se han descrito metabolitos minoritarios como glucosinolatos [4-(α-L-ramnopiranosiloxi)-bencilglucosinolato], isocianatos [pterigospermina, (4-(α-L-ramno-siloxi)-bencilisotiocianato],[4(4´-0-acetil-α-L-ramnosiloxi)-bencilisotiocianato], dipéptidos (acetato de aurantiamida) y derivados de urea (1,3-dibencil-urea) (Föster et al., 2015;

Table 5. Compounds isolated from different parts of *M. oleifera* and their biological activities.

Compound	Biological activity	Reference
4(βL-rhamnosyloxy)-benzyl isothiocyanate or Pterygospermin (Rb, S)	Antibiotic and fungicide. Associated with inhibition of TNF-α and IL-2, reduces demyelination and axonal loss, useful for multiple sclerosis	3, 9
4-(4'-0-acetyl-β-L-rhamnosyloxy)-benzyl isothiocyanate (L)	Associated with inhibition of TNF-α and IL-2	3
4-(β-D-glucopyranosyl -1→4-β-L- rhamnopyranosyloxy)-benzyl thiocarboxamide (S)	Antibacterial	20
Feluric, gallic and ellagic acids (L)	Antioxidant, antibacterial	30
Aurantiamide acetate, 1,3-dibenzylurea (R)	Anti-inflammatory, anti-arthritic, analgesic	3, 24
Benzoic acid 4-*0*-β-rhamnosyl-(1-->2) β-glucoside (L)	Help treat diabetes, typhoid, malaria, hypertension, stomach problems and amoebic dysentery, anti-inflammatory, analgesic	12
Chlorogenic and cryptochlorogenic acids (L)	Anti-inflammatory, antioxidant, reduces lipids in plasma and liver and acute lung injury	24, 32
Unsaturated fatty acids (So)	Nutritional and provides stability to oil	21
Alkaloids, flavonoids, diterpenes, tannins and glycosides (Ph)	Anti-inflammatory activity	3
Essential amino acids (L, S)	Aid in nutrient transport and storage	11, 14
α and β-amyrin (Sb, L)	Antimicrobial, anti-inflammatory activity	33
β-carotene, Astragalin, Isoquercetin, tocopherols, vitamin C (L)	Antioxidant	21, 32
Benzaldehyde 4-*0*-β-glucoside (L)	Help treat diabetes, typhoid, malaria, hypertension, stomach problems and amoebic dysentery, anti-inflammatory, analgesic	8, 12
Benzyl isocyanate (Fp)	Chemopreventive agent, reduces colitis	4
β-sitosterol (Sb, S, St, Fp)	Hypotensive activity, decreases cortisol synthesis, immunosuppressant, antioxidant, antibronchoconstrictor, hepatoprotective, anti-inflammatory	1, 11, 9, 13, 28
Kaempferitrin (kaempferol-3,7-0-β- dirhamnoside) (L)	Hypoglycemic	18
Kaempferol (L, Fp)	Antioxidant that protects against cancer, arthritis, obesity and inflammation	8
(-)-Catechin (S)	Antioxidant, antibacterial	28
Kaempferol derivatives, Flavonol glycosides (L)	Help treat diabetes, typhoid, malaria, hypertension, stomach problems and amoebic dysentery, anti-inflammatory, analgesic	12, 8
Sterols (So, S)	Reduces cholesterol	2
Stigmasterol (Sb)	Decreases serum cholesterol levels	5
Phenylmethanamine, 4β-D-glucopyranosyl -1-->4β-L- rhamnopyranosyloxy)-benzyl isocyanate (S)	Antibacterial	20
Gibberellin (L)	Stimulates plant growth	10
Lecithin (S)	Blood thinner	7
Myricetin (L, R)	Antioxidant, anticarcinogenic, antimutagenic, antidiabetic	29
Moringina (S)	Cardiac stimulant, bronchodilator, muscle relaxants	27

Table 5. Compounds isolated from different parts of *M. oleifera* and their biological activities. (*cont.*)

Compound	Biological activity	Reference
Moringinina (L, Rb)	Contributes to glucose homeostasis	19
N-α-L- rhamnophyranosyl vincosamide (L)	Cardioprotective agent	22
Niazimicine, Niacimicin A and B (L, S)	Inhibits TNF-α and IL-2, reduces blood pressure, chemopreventive, stimulates insulin release and antioxidant	1, 3, 6
Niaziminin, thiocarbamate (L)	Associated with tumor reduction	1
Niaziridin (L, Fp)	Facilitates the absorption of drugs (e.g. ampicillin), vitamins and nutrients through the gastrointestinal membrane	26
Niazirin (L, Fp, S)	Antitumor and antibacterial activity	26, 6
Plasmin, Thrombin (L, R)	Antimutagenic, blood anticoagulant	25
Water-soluble polysaccharides (Fp)	Immunomodulator	16
Quercetin-3-glycoside (L)	Hypoglycemic	15
Quercetin and some of its glucosides (L, Fp, S)	Antioxidant, hepatoprotective, analgesic, vasodilatory, antiplatelet, anti-arthritic, antibacterial, anti-inflammatory, antiflu	1, 19, 20, 22
Rutin (L)	Anti-inflammatory, antispasmodic, prevents cancer and hepatoprotective	22
Tocopherols: α-tocopherol,δ-tocopherol, γ-tocopherol (L, S, So)	Antioxidant	32
Vanillin (L, S, Fp)	Antioxidant	24
Vicenin-2 (L)	Promotes epithelization in open wounds	17, 31
Violaxanthin (L)	Useful in treating eye diseases	21
Vitamin A and β-carotenes (L, S, Fp)	Protect eyes, skin, and heart, is antidiarrheal, and reduces the risk of scurvy	14, 23
Vitamin C (L)	Protects against respiratory diseases	14
Zeaxanthin (L, S, Fp)	Protects against UV rays and strengthens vision	21

So = seed oil; Rb = root bark; Ps = pod husk; Sb = stembark; L = leaf; R = root; S = seed; St = stem; Fp = fresh pod; TNF-α = tumor necrosis factor actor; IL-2 = interleukin 2 or proleukin

[1]Anwar et al. (2007); [2]Anwar and Rashid (2007); [3]Arora et al. (2014); [4]Budda et al. (2011); [5]Chandrashekar, Thakur, and Prasanna (2010); [6]Cheehpracha et al. (2010); [7]de Andrade-Luz et al. (2013); [8]de Melo et al. (2009); [9]Galuppo et al. (2014); [10]Howladar (2014); [11]Ijarotimi, Adeoti, and Ariyo (2013); [12]Maguro and Lemmen (2007); [13]Mahajan & Mehta, (2011); [14]Mahmood, Mugal, and Haq (2010); [15]Middha et al. (2012); [16]Mishra et al. (2011); [17]Muhammad, Pauzi, Arlselvan, Abas, and Fakurazi (2013); [18]Ndong, Uehara, Katsumata, and Suzuki (2007); [19]Nouman et al. (2014); [20]Oluduro, Aderiye, Connolly, Akintayo, and Famurewa (2010); [21]Pinheiro-Ferreira, Farias, de Abreu-Oliveira, and Urano-Carvalho (2008); [22]Panda, Kar, Sharma, and Sharma (2013); [23]Promkun, Kupradinun, Tuntipopipat, and Butryee (2010); [24]Sashidhara et al. (2009); [25]Satish, Kumar, Rakshith, Satish, and Ahmed (2012); [26]Shanker et al., (2007); [27]Singh, Garg, Bhardwaj, and Sharma (2012b); [28]Singh et al. (2009); [29]Singh, Negi, and Radha (2013); [30]Sultana and Anwar (2008); [31]Verma, Vijayakumar, Mathela, and Rao (2009); [32]Vongsak, Sithisarn, and Gritsanapan (2013); [33]Zhao and Zhang (2013).

Medicinal properties and ethnomedical uses

Different Ayurvedic medicine books include records on the use of *M. oleifera* since the eighteenth century (Kumar, Kumar, Kumar-Singh, 2015) for the treatment of asthma, epilepsy, eye and skin diseases, fever, headache, hemorrhoids, anti-helminths, kidney stones and arthritis, among other conditions (Kumar, 2013; Sanjay & Dwivedy, 2015; Singh, 2012a).

In Africa it has been used to treat arthritis, pain in joints, head, stomach, ears and molars, as a cardiac and circulatory stimulant, to treat physical weakness, colds,

Howarth & Benin, 2011; Sashidhara et al., 2009; Waterman et al., 2014). En el Cuadro 5, se enlistan sustancias contenidas en diferentes partes de la planta.

Propiedades medicinales y usos etnomédicos

En diferentes libros de la medicina ayurvédica existen registros sobre el uso de *M. oleifera* desde el siglo XVIII a. C. (Kumar, Kumar, & Kumar-Singh, 2015) para el tratamiento de asma, epilepsia, enfermedades de los ojos y de la piel, fiebre, dolor de cabeza, hemorroides, anti-helmintos, cálculos renales, artritis, entre otros padecimientos (Kumar, 2013; Sanjay & Dwivedy, 2015; Singh, 2012a).

Cuadro 5. Compuestos aislados de diferentes partes de *M. oleifera*. y sus actividades biológicas.

Compuesto	Actividad biológica	Referencia
4(βL-ramnosiloxi) bencil isocianato o Pterigospermina (Cr, S)	Antibiótico y fungicida. Asociado a la inhibición de TNF-α e IL-2, Reduce la desmielinación y pérdida de axones, útil para esclerosis múltiple	3, 9
4-(4'-*0*-acetil-β-L-ramnosiloxi) bencil)isocianato (H)	Asociado a la inhibición de TNF-α e IL-2	3
4-(β-D-glucopiranosil-1→4-β-L-ramnopiranosiloxi)bencil tiocarboxamida (S)	Antibacterial	20
Ác.felúrico, ac.gálico, ac. elágico (H)	Antioxidante, antibacteriano	30
Acetato de aurantiamida, 1,3-dibencil-urea (R)	Antiinflamatorio, antiartrítico, analgésico	3, 24
Ácido benzoico 4-*0*-β-ramnosil-(1-->2) β-glucósido (H)	Contribuyen a mejorar diabetes, tifoidea, malaria, hipertensión, problemas estomacales y disentería amebiana, antiinflamatorio, analgésico	12
Ácido clorogénico y cripto clorogénico (H)	Antiinflamatorio, antioxidante, reduce lípidos en plasma e hígado y daño agudo a pulmón	24, 32
Ácidos grasos insaturados (ACs)	Nutricional y estabilidad al aceite	21
Alcaloides, flavonoides, diterpenos, taninos y glicósidos (Cv)	Actividad antiinflamatoria	3
Aminoácidos esenciales (H, S)	Ayudan en el transporte y almacenamiento de nutrientes	11, 14
A y β-amirina (Ct, H)	Actividad antimicrobiana, antiinflamatoria	33
β-caroteno, Astragalina, Isoquercetina, tocoferoles, vitaminas C (H)	Antioxidante	21, 32
Benzaldehído 4-0-β-glucósido (H)	Contribuyen a mejorar diabetes, tifoidea, malaria, hipertensión, problemas estomacales y disentería amebiana, antiinflamatorio, analgésico	8, 12
Bencil isocianato (Vf)	Agente quimiopreventivo, reduce colitis,	4
β-sitosterol (Ct, S, T, Vf)	Actividad hipotensivo, disminuye la síntesis de cortisol, inmunosupresor, antioxidante, antibroncoconstrictor, hepatoprotector, antiinflamatorio,	1, 11, 9, 13, 28
Caempferitrina (caempferol-3,7-*0*-β-diramnósido) (H)	Hipoglicémico	18
Caempferol (H, Vf)	Antioxidante que protege contra cáncer, artritis, obesidad e inflamación	8
(-)-Catequina (S)	Antioxidante, antibacteriano	28
Derivados del campferol, Flavonol glucósidos (H)	Contribuyen a mejorar diabetes, tifoidea, malaria, hipertensión, problemas estomacales y disentería amebiana, antiinflamatorio, analgésico	12, 8
Esteroles (ACs, S)	Reducen colesterol	2
Estigmasterol (Ct)	Disminuye niveles séricos de colesterol	5
Fenilmetanamina, 4β-D-glucopiranosil-1-->4β-L-ramnopiranosiloxil)-bencil isocianato (S)	Antibacteriana	20
Giberelina (H)	Estimula crecimiento de plantas	10
Lecticina (S)	Anticoagulante sanguíneo	7
Miricetina (H, R)	Antioxidante, anticancerígeno, antimutagénico, antidiabético,	29
Moringina (S)	Estimulante cardiaco, broncodilatador, desestresante muscular	27
Moringinina (H, Cr)	Contribuye en la homeostasis de la glucosa	19

Cuadro 5. Compuestos aislados de diferentes partes de *M. oleifera*. y sus actividades biológicas. (*cont.*)

Compuesto	Actividad biológica	Referencia
N-α-L-ramnofiranosil vincosamida (H)	Cardioprotector	22
Niazimicina, Niacimicina A y B (H, S)	Inhibe TNF-α e IL-2, Reducen presión sanguínea, quimiopreventivo, estimula la liberación de insulina y antioxidante	1, 3, 6
Niaziminina, tiocarbamato (H)	Asociado con la reducción de tumores	1
Niaziridina (H, Vf)	Facilita la absorción de fármacos (ie: ampicilina), vitaminas y nutrientes a través membrana gastrointestinal	26
Niazirina (H, Vf, S)	Actividad antitumoral y antibacteriana	26, 6
Plasmina, Trombina (H, R)	Antimutagénico, anticoagulante sanguíneo	25
Polisacáridos hidrosolubles (Vf)	Inmunomodulador	16
Quercetin-3-glicosido (H)	Hipoglicémico	15
Quercetina y algunos de sus glucósidos (H, Vf, S)	Antioxidante, hepatoprotector, analgésico, vasodilatador, antiagregante, antiartrítico, antibacteriano, antiinflamatorio, antigripal	1, 19, 20, 22
Rutina (H)	Antinflamatoria, antiespasmódica, previene el cáncer y hepatoprotector	22
Tocoferoles: a-tocoferol,d-tocoferol, g-tocoferol (H, S, ACs)	Antioxidante	32
Vainillina (H, S, Vf)	Antioxidante	24
Vicenina-2 (H)	Favorece la epitelización en heridas expuestas	17, 31
Violaxantina (H)	Útil en enfermedades oculares	21
Vitamina A y β-carotenos (H, S, Vf)	Protege la vista, la piel, corazón y es antidiarreico. Disminuye el riesgo de Escorbuto	14, 23
Vitamina C (H)	Protege contra enfermedades respiratorias	14
Zeaxantina (H, S, Vf)	Protege contra rayos uv y fortalece la vista	21

ACs= aceite de semilla; Cr = corteza de raíz; Cv = cáscara de vaina; Ct = corteza de tallo; H = hoja; R = raíz; S = semilla; T = tallo; Vf = vaina fresca; TNF-α = factor de necrosis tumoral; IL-2 = interleuquina 2 o proleuquina

[1]Anwar et al. (2007); [2]Anwar y Rashid (2007); [3]Arora et al. (2014); [4]Budda et al. (2011); [5]Chandrashekar, Thakur, y Prasanna (2010); [6]Cheehpracha et al. (2010); [7]de Andrade-Luz et al. (2013); [8]de Melo et al. (2009); [9]Galuppo et al. (2014); [10]Howladar (2014); [11]Ijarotimi, Adeoti, y Ariyo (2013); [12]Maguro y Lemmen (2007); [13]Mahajan & Mehta, (2011); [14]Mahmood, Mugal, y Haq (2010); [15]Middha et al. (2012); [16]Mishra et al. (2011); [17]Muhammad, Pauzi, Arlselvan, Abas, y Fakurazi (2013); [18]Ndong, Uehara, Katsumata, y Suzuki (2007); [19]Nouman et al. (2014); [20]Oluduro, Aderiye, Connolly, Akintayo, y Famurewa (2010); [21]Pinheiro-Ferreira, Farias, de Abreu-Oliveira, y Urano-Carvalho (2008); [22]Panda, Kar, Sharma, y Sharma (2013); [23]Promkun, Kupradinun, Tuntipopipat, y Butryee (2010); [24]Sashidhara et al. (2009); [25]Satish, Kumar, Rakshith, Satish, y Ahmed (2012); [26]Shanker et al., (2007); [27]Singh, Garg, Bhardwaj, y Sharma (2012b); [28]Singh et al. (2009); [29]Singh, Negi, y Radha (2013); [30]Sultana, y Anwar (2008); [31]Verma, Vijayakumar, Mathela, y Rao (2009); [32]Vongsak, Sithisarn, y Gritsanapan (2013); [33]Zhao y Zhang (2013).

stomach worms, fever, kidney and liver problems, epilepsy, anemia, ulcers, delirium, snakebite, as a rubefacient, among others (Lim, 2012; Popoola & Obeme, 2013). In some Latin American countries, it is used to treat asthma, flu, cough, colic, flatulence, gastritis, headache, fever and itching (Torres, Méndez, Durán, Boulogne, & Germosén, 2015).

Pharmacological studies

Several biological studies (Table 6) conducted with *M. oleifera* have highlighted the antioxidant activity in vitro of the leaf, root, seed, flower and stem bark, attributable to the presence of polyphenols, alkaloids, saponins, carotenes, minerals, amino acids and sterols (Luqman, Srivastava, Kumar, Maurya, & Chanda,

En poblaciones de África se ha usado para tratar artritis, dolor en articulaciones, cabeza, estómago, oídos y muelas, como estimulante cardiaco y circulatorio, para tratar debilidad corporal, catarros, lombrices estomacales, fiebre, problemas de riñón e hígado, epilepsia, anemia, ulceras, delirio, mordedura de serpiente, como rubefaciente, entre otros (Lim, 2012; Popoola & Obeme, 2013). En algunos países de Latinoamérica, se utiliza para tratar asma, gripe, tos, cólico, flatulencias, gastritis, dolor de cabeza, fiebre y comezón (Torres, Méndez, Durán, Boulogne, & Germosén, 2015).

Estudios farmacológicos

En diversas investigaciones biológicas (Cuadro 6) que se han realizado con *M. oleifera* destacan la actividad

Table 6. Medicinal properties of *Moringa oleifera* Lam.

Ailment	Part of the plant used							Ailment	Part of the plant used						
Abortifacient	B	F	G	L	R			Bronchitis				L			
Aphrodisiac		F						Carminative					R		
Enlarged spleen	B	F						Night and childhood blindness				L			P
Analgesic	B		G	L	R			Heal wounds				L			
Anemia				L		S		Diarrhea				L			
Antimicrobial	B	F		L	R	S		Dysentery			G				
Anti-asthmatic			G			S		Decreases cholesterol levels		F		L			
Anticancer				L		S		Diuretic	B	F	G	L	R	S	
Anticlastogen							P	Scurvy				L			
Antidiabetic				L				Cardiac-circulatory stimulant		F	G	L	R	S	P
Antispasmodic	B	F		L	R	S		Stimulant in paralysis					R		
Antifertility	B				R			Hemorrhoids				L			
Anti-inflammatory	B	F		L	R	S	P	Hepatoprotective agent		F		L	R		
Antilithic					R			Hypotensive				L			
Antihypertensive				L				Eye and ear Infections				L			
Anthelmintic		F						Immunomodulator (cellular, humoral)							
Antimalarial (larvicide)						S		Laxative				L			
Antioxidant	B			L	R	S		Purgative				L			
Antipyretic				L		S		Radioprotector				L			
Antitumor agent	B			L		S		Rheumatism			G		R		
Anti-ulcerogenic agent	B	F		L	R			Regulates hyperthyroidism				L			
Anti-urolithiasic agent					R			Rubefacient	B		G		R		
								Vesicant	B				R		

B = bark; F = flower; G = gum; H = leaf; R = root; S = seed; P = pod
Aney et al. (2009); Dubey et al. (2013); Fahey (2005); Lim (2012); Panchal, Murti, Lambole, and Gajera (2010); Popoola and Obeme (2013)

Cuadro 6. Propiedades medicinales de *Moringa oleifera* Lam.

Padecimiento	Parte de la planta utilizada							Padecimiento	Parte de la planta utilizada						
Abortifaciente	C	F	G	H	R			Bronquitis				H			
Afrodisiaco		F						Carminativo					R		
Agrandamiento de bazo	C	F						Ceguera nocturna e infantil				H			V
Analgésico	C		G	H	R			Curar heridas				H			
Anemia				H		S		Diarrea				H			
Anitimicrobiano	C	F		H	R	S		Disenteria			G				
Antiasmático			G			S		Disminuye de niveles de colesterol		F		H			
Anticancerígeno				H		S		Diurético	C	F	G	H	R	S	
Anticlastogénico							V	Escorbuto				H			
Antidiabético				H				Estimulante cardiaco-circulatorio		F	G	H	R	S	V
Antiespasmódico	C	F		H	R	S		Estimulante en parálisis					R		
Antifertilidad	C				R			Hemorroides				H			
Anti-inflamatorio	C	F		H	R	S	V	Hepatoprotector		F		H	R		
Antilítico					R			Hipotensivo				H			
Antihipertensivo				H				Infección de ojos y oidos				H			
Antihelmíntico		F						Inmunomodulador (celular, humoral)							
Antimalárico (larvicida)						S		Laxante				H			
Antioxidante	C			H	R	S		Purgativo				H			
Antipirético				H		S		Radioprotector				H			
Antitumoral	C			H		S		Reumatismo			G		R		
Antiulcerogénico	C	F		H	R			Regula hipertiroidismo				H			
Antiuroliasico					R			Rubefaciente	C		G		R		
								Vesicante	C				R		

C = corteza; F = flor; G = goma; H = hoja; R = raíz; S = semilla; V = vaina
Aney et al. (2009); Dubey et al. (2013); Fahey (2005); Lim (2012); Panchal, Murti, Lambole, y Gajera (2010); Popoola y Obeme (2013)

2012; Kumbhare, Guleha, & Sivakumar, 2012; Moyo, Oyedemi, Masika, & Muchenje, 2012). Their antioxidant activity has been determined by various colorimetric methods such as DPPH (2,2-diphenyl-1-picrylhydrazy), ABTS [2,2'-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid], LPO (lipid peroxidation) , FRAP (ferric reducing antioxidant power), among others.

Fresh crushed leaves of *M. oleifera* showed better antioxidant activity than other species. Pakade, Cukrowskai, and Chimuka (2013) report that the total phenolics content (TPC) and the total flavonoids content (TFC) was higher (24.4 ± 8.7 and 58.7 ± 3.0 $g \cdot kg^{-1}$ dry weight), compared with other vegetables such as cauliflower (14.7 ± 3.9 and 4.6 ± 4.4 $g \cdot kg^{-1}$ dry weight), spinach (14.4 ± 2.6 and 12.5 ± 3.1 $g \cdot kg^{-1}$ dry weight), cabbage (11.8 ± 6 and 9.8 ± 6.1 $g \cdot kg^{-1}$ dry weight), broccoli (17.6 ± 2.9 and 15.7 ± 2.2 $g \cdot kg^{-1}$ dry weight) or peas (10.4 ± 7.9 and 6.4 ± 5.8 $g \cdot kg^{-1}$ dry weight).

Studies with extracts of flower (Alhakmani et al., 2013), leaf (Kumbhare & Sivakumar, 2011; Mcknight et al., 2014; Singh et al., 2012b; Sulaiman et al., 2008), pod (Cheehpracha et al., 2010), root (Georgewill, Georgewill, & Nwankoala, 2010) and seed (Correa-Araújo et al., 2013; Mahajan, Mali, & Mehta, 2007; Mahajan & Mehta, 2010; Mahajan & Mehta, 2011) show anti-inflammatory activity in models *in vivo* and *in vitro*.

Leaf extracts show activity against Gram-negative bacteria (Escherichia coli and Salmonella typhi) at 400 $mg \cdot mL^{-1}$ (Urmi, Masum, Zulfiker, Hossain, & Hamid, 2012), and against Gram-positive bacteria and fungi where the minimum inhibitory concentration was 200 $mg \cdot mL^{-1}$ (Adline & Devi, 2014; Gami & Parabia, 2011; Gomashe, Gulhane, Junghare, & Dhakate 2014; Ojiako, 2014), as well as antiviral activity against the viruses of foot and mouth disease, *Herpes equino*, *Herpes simplex*, Epstein bar, Hepatitis, Rhinovirus and HIV (Younus et al., 2015). It also inhibits the growth of larvae of *Anopheles gambiaes* (Chuang et al., 2007; Prabhu, Murugan, Nareshkumar, Ramasubramanian, & Bragadeeswaran, 2011) and *Aedes aegypti* (vector for the dengue virus), attributed to its content of β-amyrin, β-sitosterol, kaempferol and quercetin (Pontual et al., 2012).

The flower extracts showed anti-bacterial activity against *B. subtilis, S. aureus, E. coli, K. pneumoniae* and anti-fungal against *C. albicans* (Talreja, 2010), and the seed extracts against *K. pneumonia, P. vulgaris, E. coli, P. fluorescens, A. baumannil, B. cepacia, P. mirabilis, S. rubidae, S. pullorum,* and *K. oxycota* (Oluduro et al., 2010). The stembark showed activity against *E. coli, S. aureus, P. aeruginosa* and *S. epidermis* (Kumbhare et al., 2012), and the oil against *T. rubrum, T. mentagrophytes, E. floccosum* and *M. canu*. The pod husk extract showed activity against *S. aureus, S. epidermis, S. thyphimurium* and *E.*

antioxidante *in vitro* de la hoja, raíz, semilla, flor y corteza de tallo; esto, atribuible a la presencia de polifenoles, alcaloides, saponinas, carotenos, minerales, aminoácidos y esteroles (Luqman, Srivastava, Kumar, Maurya, & Chanda, 2012; Kumbhare, Guleha, & Sivakumar, 2012; Moyo, Oyedemi, Masika, & Muchenje, 2012). Su actividad antioxidante se ha determinado por diversos métodos colorimétricos como DPPH (2,2 difenil-1-picrilhidrazilo), ABTS [ácido 2,2'-azino-bis-(3-etilbenzotiazolin-6-sulfónico], LPO (peroxidación lípida), FRAP (poder antioxidante reductor del hierro), entre otros.

Las hojas frescas machacadas de *M. oleifera* mostraron mejor actividad antioxidante que otras especies. Pakade, Cukrowskai, y Chimuka (2013) reportan que el contenido de fenoles totales (TPC) y el contenido total de flavonoides (TFC) fue mayor (24.4 ± 8.7 y 58.7 ± 3.0 $g \cdot kg^{-1}$ de peso seco), en comparación con otros vegetales como la coliflor (14.7 ± 3.9 y 4.6 ± 4.4 $g \cdot kg^{-1}$ de peso seco), espinaca (14.4 ± 2.6 y 12.5 ± 3.1 $g \cdot kg^{-1}$ de peso seco), col (11.8 ± 6 y 9.8 ± 6.1 $g \cdot kg^{-1}$ de peso seco), brócoli (17.6 ± 2.9 y 15.7 ± 2.2 $g \cdot kg^{-1}$ de peso seco) o chicharos (10.4 ± 7.9 y 6.4 ± 5.8 $g \cdot kg^{-1}$ de peso seco).

Estudios realizados con extractos de la flor (Alhakmani et al., 2013), hoja (Kumbhare & Sivakumar, 2011; Mcknight et al., 2014; Singh et al., 2012b; Sulaiman et al., 2008), vaina (Cheehpracha et al., 2010), raíz (Georgewill, Georgewill, & Nwankoala, 2010) y semilla (Correa-Araújo et al., 2013; Mahajan, Mali, & Mehta, 2007; Mahajan & Mehta, 2010; Mahajan & Mehta, 2011), reportan actividad antiinflamatoria en modelos *in vivo* e *in vitro*.

Los extractos de hojas tienen actividad contra bacterias Gram negativas (*Escherichia coli* y *Salmonella typhi*) a 400 $mg \cdot mL^{-1}$ (Urmi, Masum, Zulfiker, Hossain, & Hamid, 2012), y contra Gram positivas y hongos la concentración mínima inhibitoria fue 200 $mg \cdot mL^{-1}$ (Adline & Devi, 2014; Gami & Parabia, 2011; Gomashe, Gulhane, Junghare, & Dhakate 2014; Ojiako, 2014); así como, actividad antiviral contra virus de la fiebre aftosa, *Herpes equino, Herpes simplex*, Epstein bar, Hepatitis, Rinovirus y HVI (Younus et al., 2015). También, tiene actividad inhibitoria del crecimiento de larvas de *Anopheles gambiaes* (Chuang et al., 2007; Prabhu, Murugan, Nareshkumar, Ramasubramanian, & Bragadeeswaran, 2011) y *Aedes aegypti* (transmisor del dengue), atribuida a su contenido de β-amirina, β-sitosterol, caempferol y quercetina (Pontual et al., 2012).

Los extractos de flores presentaron actividad antibacteriana contra *B. subtilis, S. aureus, E. coli, K. pneumoniae* y anti-antifungica contra *C. albicans* (Talreja, 2010), y los de semilla contra *K. pneumonia, P. vulgaris, E. coli, P. fluorescens, A. baumannil, B. cepacia, P. mirabilis, S.*

coli (Arora et al., 2014). In the root the presence of pterygospermin, an isocyanate with antibacterial use, was identified (Howarth & Benin, 2011).

Uses of *Moringa oleifera* Lam.

Agroindustrial

The ethanolic and aqueous extract of *M. oleifera* leaf is used as a biofomenter because it contributes to increased nodules and weight in roots because of its content of plant hormones such as gibberellin and zeatin; it also reduces the stress generated by excess NaCl and $Cd^{(2)}$, increases productivity due to the antioxidant activity that occurs in some crops (Howladar, 2014; Rady, Varma, & Howladar, 2013) and is used as a fungicide on tomato crops (Yousaf et al., 2015); in addition, activated carbon is obtained from the embryo, seed husks and stemwood (Kalavathy & Miranda, 2010).

The oil extracted from the seed, with yields of up to 39 %, is used to make cosmetics (as a skin moisturizer, conditioner and emollient) and as an ingredient in soaps, salves, creams and sunscreen (Aney et al., 2009; Ayerza, 2012; Cefali, Ataide, Moriel, Foglio, & Mazzola, 2016). The oil and mature leaves are used as a preservative (Bijina et al., 2011) and as a food fortificant (Oyeyinka & Oyeyinka, 2016), due to the high concentration of antioxidants (which are trypsin and protease inhibitors). The flowers have caseinolytic activity due to the presence of aspartic, cysteine, serine and protease-dependent calcium ions, creating a potential application in the dairy industry (Pontual et al., 2012).

Fodder

The leaves and stems have fodder potential, appreciated in dry seasons because they grow quickly and require little water (Nouman et al., 2014; Soliva et al., 2005); both contain 23 and 9 % protein and have 79 and 57 % digestibility, respectively (Liñan, 2010). By supplying it to ruminants, as part of their diet, increased milk production and weight was observed (Mahmood et al., 2010; Mendieta, Spörndly, Reyes, & Spörndly, 2011). In poultry it improved growth, food digestion, intestinal health, skin color (Donkor, Kwame-Glover, Addae, & Kubi, 2013; Melesse, Getye, Berihum, & Banerjee, 2013; Nkukwana et al., 2014a; Nkukwana et al., 2014b) and egg production (Kana et al., 2015). The use of moringa leaves in rabbit diets resulted in weight gain (Abbas, 2013; Caro, Bustamante, Dihigo, & Ly, 2013), and in growing pigs it improved digestibility from 55.7 to 65.8 %, by being a source of protein (García & Macias, 2014; Muthukumar, Naveena, Vaithiyanathan, Sen, & Sureshkumar, 2014; Ly, Samkol, Phiny, Bustamante, & Caro, 2016). In the diet of Nile tilapia fingerlings,

rubidae, S. pullorum, K. oxycota (Oluduro et al., 2010). La corteza del tallo mostró actividad contra *E. coli, S. aureus, P. aeruginosa* y *S. epidermis* (Kumbhare et al., 2012), y el aceite contra *T. rubrum, T. mentagrophytes, E. floccosum* y *M. canu*. El extracto de la cáscara de vaina presentó actividad contra *S. aureus, S. epidermis, S. thyphimurium* y *E. coli* (Arora et al., 2014). En la raíz se identificó la presencia de pterygospermina, un isocianato con uso antibacteriano (Howarth & Benin, 2011).

Usos de *Moringa oleifera* Lam.

Agroindustrial

El extracto etanólico y acuoso de la hoja de *M. oleifera* se usa como biofomentador porque contribuye al aumento de nódulos y peso en raíces debido a su contenido de fitohormonas como giberelina y zeatina; asimismo, reduce el estrés generado por exceso de NaCl y $Cd^{(2)}$, aumenta la productividad debido a la actividad antioxidante que presenta en algunos cultivos (Howladar, 2014; Rady, Varma, & Howladar, 2013) y se usa como fungicida en plantaciones de tomate (Yousaf et al., 2015); además, se obtiene carbón activado a partir del embrión, cáscara de semilla y de madera del tallo (Kalavathy & Miranda, 2010).

El aceite extraído de la semilla, con rendimiento de hasta 39 %, se utiliza para elaborar cosméticos (como humectante), acondicionador y como emoliente, como ingrediente en jabones, bálsamos, cremas y protector solar (Aney et al., 2009; Ayerza, 2012; Cefali, Ataide, Moriel, Foglio, & Mazzola, 2016). El aceite y las hojas maduras se usan como conservador (Bijina et al., 2011) y fortificante de alimentos (Oyeyinka & Oyeyinka, 2016), debido a la concentración alta de sustancias antioxidantes (que son inhibidoras de tripsina y proteasa). Las flores tienen actividad caseinolitica debido a la presencia de aspártico, cisteína, serina e iones de calcio dependientes de la proteasa, lo que genera una aplicación potencial en la industria de los lácteos (Pontual et al., 2012).

Forrajero

Las hojas y los tallos tienen potencial forrajero, apreciados en temporadas secas porque crecen rápido y requieren poca agua (Nouman et al., 2014; Soliva et al., 2005); ambos contienen 23 y 9 % de proteína y 79 y 57 % de digestibilidad, respectivamente (Liñan, 2010). Al suministrar a rumiantes, como parte de su dieta, se observó aumentó en la producción de leche y peso (Mahmood et al., 2010; Mendieta, Spörndly, Reyes, & Spörndly, 2011). En aves de corral mejoró el crecimiento, la digestión del alimento, la salud intestinal, la coloración de la piel (Donkor, Kwame-Glover, Addae, & Kubi, 2013; Melesse, Getye, Berihum, & Banerjee, 2013; Nkukwana et al., 2014a; Nkukwana it is recommended to replace soybean meal with moringa leaf by up to 7 % (Tiamiyu, Okomoda, & Aonde, 2016).

Moreover, the leaves as fodder can serve as a substitute for antibiotics because of their antimicrobial activity (Melesse et al., 2012). Likewise, the leaf, pod and root are used to treat livestock with diarrhea, dysentery, rheumatism and ulcers (Parthiban, Vijayakumar, Prabhu, & Yabesh, 2016; Verma, 2014).

Biofuels

Moringa seed oil has been considered as a potential source of biodiesel for use in motor vehicles, due to its low temperature, lubricity and high viscosity index, all without the need to modify it, thereby producing clean emissions within the ASTM D6751 and EN 14214 standards (Mofijur et al., 2014; Rahman et al., 2014; Sharma et al., 2009). Oil production could generate between 1,000 and 2,000 $L \cdot ha^{-1}$, with a cetane number of nearly 67, high oxidation stability and a high freezing point (Karmakar, Karmakar, & Mukherjee, 2010), especially if the Periyakalum-1 variety, designed to increase pod and seed production, is used (Ayerza, 2012). It is also used as the basis for ethanol production (Hernández et al., 2013).

Water treatment

Seed powder, with and without the husk, has coagulant, flocculant, water softening and disinfectant effects (Bichi, 2013; Jeon et al., 2009; Suhartini, Hidayat, & Rosaliana, 2013). It can be used in the treatment of river water with suspended solids, and groundwater contaminated by various sources: synthetic effluents (Aziz et al., 2015; Lijesh & Malhotra, 2016; Sasikala & Muthurama, 2015), tannery effluents, palm oil mill effluents and waste from the concrete industry, (de Paula, de Oliveira-Ilha, & Santos-Andrade, 2016), paper industry (Area, Ojeda, Barboza, Bengoechea, & Felissia, 2010) and textile industry (Beltrán-Heredia, Sánchez-Martín, Muñoz-Serrano, & Peres, 2012b). It is also used to remove color, turbidity, fecal colloids, helminths and bacteria such as *Echerichia coli*. However, the use of moringa seed is less efficient than some commercial coagulants such as aluminum sulfate and ferric sulfate, but its low cost and biodegradability makes it a potential candidate in developing countries (Anwar, Latif, Ashraf, & Gilanni, 2007; Goja & Osman, 2013; Muthuraman & Sasikala, 2014; Pritchard, Craven, Mkandawire, Edmosnon, & O'neil 2010; Suhartini et al., 2013).

Efficacy as a coagulant is better the higher the turbidity level (Sánchez-Martín, Ghebremichael, & Beltrán-Heredia, 2010) in an alkaline medium and at

et al., 2014b) y la producción de huevo (Kana et al., 2015). El uso de hojas de moringa en la dieta en conejos mostró ganancia de peso (Abbas, 2013; Caro, Bustamante, Dihigo, & Ly, 2013), y en cerdos en crecimiento se mejoró la digestibilidad de 55.7 a 65.8 %, por ser fuente de proteína (García & Macias, 2014; Muthukumar, Naveena, Vaithiyanathan, Sen, & Sureshkumar, 2014; Ly, Samkol, Phiny, Bustamante, & Caro, 2016). En la cría de tilapia de río se recomienda sustituir la alimentación con soya por moringa hasta 7 % (Tiamiyu, Okomoda, & Aonde, 2016).

Por otra parte, las hojas como forraje pueden ser sustituto de antibióticos debido a su actividad antimicrobiana (Melesse et al., 2012). Asimismo, la hoja, vaina y raíz se usan en el tratamiento de ganado con diarrea, disentería, reumatismo y úlceras (Parthiban, Vijayakumar, Prabhu, & Yabesh, 2016; Verma, 2014).

Biocombustibles

El aceite de semilla de moringa ha sido considerado fuente potencial de biodiesel para usarse en los motores de vehículos, por su baja temperatura, lubricidad y alto índice de viscosidad; lo anterior sin necesidad de modificarlo, produciendo emisiones limpias dentro de los estándares de la ASTM D6751 y EN 14214 (Mofijur et al., 2014; Rahman et al., 2014; Sharma et al., 2009). La producción de aceite podría generar entre 1,000 y 2,000 $L \cdot ha^{-1}$, con número de cetano de casi 67, alta estabilidad oxidativa y alto punto de congelamiento (Karmakar, Karmakar, & Mukherjee, 2010); especialmente si se cultiva la variedad Periyakalum-1, diseñada para aumentar la producción de vaina y semilla (Ayerza, 2012). Igualmente, se usa como base para la producción de etanol (Hernández et al., 2013).

Tratamiento de agua

La semilla en polvo, con y sin cáscara, tiene efecto coagulante y floculante, suavizador de agua y desinfectante (Bichi, 2013; Jeon et al., 2009; Suhartini, Hidayat, & Rosaliana, 2013). Puede usarse en el tratamiento de aguas de río con sólidos suspendidos, subterráneas contaminadas por diversas fuentes: efluentes sintéticos (Aziz et al., 2015; Lijesh & Malhotra, 2016; Sasikala & Muthurama, 2015), efluentes de procesos de curtiduría, residuos de aceite de palma, desechos de la industria del concreto (de Paula, de Oliveira-Ilha, & Santos-Andrade, 2016), industria del papel (Area, Ojeda, Barboza, Bengoechea, & Felissia, 2010) e industria textil (Beltrán-Heredia, Sánchez-Martín, Muñoz-Serrano, & Peres, 2012b); así como para remover color, turbidez, coloides fecales, helmintos y bacterias como *Echerichia coli*. Sin embargo, el uso de semilla es menos eficiente que algunos coagulantes comerciales como el sulfato high temperatures (Pritchard et al., 2010). It removes calcium, magnesium, iron, manganese, strontium, aluminum (Bichi, 2013), cadmium (Abedini & Alpour, 2015), nitrates (Rezende et al., 2016), textile dyes (Beltrán-Heredia et al., 2012b), nitrobenzene (Tavengwa, Cukrowska, & Chimuka, 2016) and anionic surfactants such as detergents (Beltrán-Heredia, Sánchez-Martín, & Barrado-Moreno, 2012a). Other parts of the plant have also been shown to facilitate cleaning water, such as the bark, which has been used to remove Ni, Pb, Na, K, Ca and Mg (Reddy, Seshaiah, Reddy, Rao, & Wang, 2010b; Reddy, Ramana, Seshaiah, & Reddy, 2011); the leaf has been used to remove lead (Reddy, Harinath, Seshaiah, & Reddy, 2010a) and mixed with activated carbon it has been used to remove Cu, Ni and Zn (Kalavathy & Miranda, 2010).

Conclusions

So far, studies indicate that *Moringa oleifera* has various bioactive chemical compounds, is useful for human and animal consumption, for the treatment of some diseases and as raw material in the cosmetics industry. This plant represents an environmentally-friendly alternative for the sustainable development of the food, health and technology industries. However, the existing information is insufficient to generate technology and apply it; therefore, further research is needed on the production system, processes and products for use in agro-industry and by the consumer.

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de aluminio y el sulfato férrico, pero su bajo costo y biodegradabilidad la hace candidata potencial en países en vías de desarrollo (Anwar, Latif, Ashraf, & Gilanni, 2007; Goja & Osman, 2013; Muthuraman & Sasikala, 2014; Pritchard, Craven, Mkandawire, Edmosnon, & O'neil 2010; Suhartini et al., 2013).

La efectividad como coagulante es mejor a mayor nivel de turbidez (Sánchez-Martín, Ghebremichael, & Beltrán-Heredia, 2010) en medio alcalino y temperaturas altas (Pritchard et al., 2010). Remueve calcio, magnesio, hierro, manganeso, estonio, aluminio (Bichi, 2013), cadmio (Abedini & Alpour, 2015), nitratos (Rezende et al., 2016), colorantes textiles (Beltrán-Heredia et al., 2012b), nitrobenceno (Tavengwa, Cukrowska, & Chimuka, 2016) y surfactantes aniónicos como detergentes (Beltrán-Heredia, Sánchez-Martín, & Barrado-Moreno, 2012a). Otras partes de la planta también han mostrado facilitar la limpieza del agua, como la corteza, mediante la cual se ha logrado remover Ni, Pb, Na, K, Ca y Mg (Reddy, Seshaiah, Reddy, Rao, & Wang, 2010b; Reddy, Ramana, Seshaiah, & Reddy, 2011), con la hoja se quita el plomo (Reddy, Harinath, Seshaiah, & Reddy, 2010a) y mezclado con carbón activado se ha usado en la remoción de Cu, Ni y Zn (Kalavathy & Miranda, 2010).

Conclusiones

Hasta el momento, los estudios realizados indican que *Moringa oleifera* posee diversos compuestos químicos bioactivos, es útil para consumo humano y animal, para el tratamiento de algunas enfermedades y como materia prima en la industria de cosméticos. Esta planta representa una alternativa para el desarrollo sustentable de la alimentación, salud y tecnología, sin dañar el ambiente. Sin embargo, la información existente no es suficiente para generar tecnología y aplicarla; por ello, es necesario realizar investigaciones sobre el sistema de producción, procesos y productos para ser utilizados en la agroindustria y por el consumidor.

Fin de la versión en español

References / Referencias

Abbas, T. E. (2013). The use of *Moringa oleifera* in poultry diets. *Turkish Journal of veterinary and Animal Sciences*, *37*, 492-496. doi: 10.3906/vet-1211-40

Abdull, R. M., Ibrahim, M. D., & Kntayya, S. B. (2014). Health benefits of *Moringa oleifera*. *Asian Pacific Journal of Cancer Prevention*, *15*, 8571-8576. doi: 10.7314/APJCP.2014.15.20.8571

Abedini, S., & Alpour, V. (2015). Cadmium removal from synthetic wastewater by using *Moringa oleifera* seed powder. *Environmental Health Engineering Management Journal*, *2*(4), 157-163. Retrieved from http://www.ehemj.com/browse.php?a_id=114&slc_lang=en&sid=1&ftxt=1

Adline, J., & Devi, A. (2014). A study on phytochemical screening and antibacterial activity of *Moringa oleifera*. *International Journal of Research in Applied, Natural and Social Sciences*, *2*(5), 169-176.

Al-anizi, A. A., Hellyer, M. T., & Zhang, D. (2014). Toxicity assessment and modelling of *Moringa oleifera* seeds in water purification by whole cell bioreporter. *Water Research*, *56*, 77-87. doi: 10.1016/j.watres.2014.02.045

Alhakmani, F., Kumar, S., & Khan, S. A. (2013). Estimation of total phenolic content, *in-vitro* antioxidant and anti-inflammatory activity of flowers of *Moringa oleifera*. *Asian Pacific Journal of Tropical Biomedicine*, *3*(8), 623-627. doi: 10.1016%2FS2221-1691(13)60126-4

Amaglo, N., Bennett, R. N., Lo Curto, R., Rosa, E., Lo Turco, V., Giuffrida, A., Lo Curto, A., Crea, F., & Timpo, G. M. (2010). Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. *Food Chemistry*, *122*(4), 1047-1054. doi: 10.1016/j.foodchem.2010.03.073

Aney, J. S, Rashmi, T., Maushumi, K., & Kiran, B. (2009). Pharmacological and pharmaceutical potential of *Moringa oleifera:* A review. *Journal of Pharmacy Research, 2*(9), 1424-1426. Retrieved from http://jprsolutions.info/newfiles/journal-file-56b3fecbe505c6.43079591.pdf

Anwar, F., Latif, S., Ashraf, M., & Gilanni, A. H. (2007). *Moringa oleifera*: A food plant with multiple medicinal uses. *Phytotherapy Research*, *21*(1), 17-25. doi: 10.1002/ptr.2023

Anwar, F., & Rashid, U. (2007). Physico-chemical characteristics of *Moringa oleifera* seeds and seed oil from a wild provenance of Pakistan. *Pakistan Journal of. Botany*, *39*(5), 1443-1453.

Area, M. C., Ojeda, S. A., Barboza, O. M., Bengoechea, D. I., & Felissia, F. E. (2010). Tratamientos aplicables para la reducción de la DQO recalcitrante de efluentes de pulpados quimimecánicos y semiquímicos (revisión). *Revista de Ciencia y Tecnología*, *12*(13), 4-12.

Arora, R., Malhotra, P., Sharma, A., Haniadka, R., Yashawanth, H. S., & Baliga, M. S. (2014) Medicinal efficacy of indian herbal remedies for the treatment of arthritis. In Ross, R., Watson, V., & Preedy, R. (Eds.), *Bioactive Food as Dietary Interventions for Arthritis and Related Inflammatory Diseases* (pp. 601-617). USA: Academic Press. doi: 10.1016/B978-0-12-397156-2.00250-7

Asare, G. A., Gyan, B., Bugyei, K., Adjei, S., Mahama, R., Addob, P., Otu-Nyarko, L., Wiredu, E. K., & Nyarkob, A. (2012). Toxicity potentials of the nutraceutical *Moringa oleifera* at supra-supplementation levels. *Journal of Ethnopharmacology*, *139*(1), 265-272. doi: 10.1016/j.jep.2011.11.009

Ashworth, A., & Ferguson, E. (2008). Dietary counselling in the management of moderately malnourished children. Retrieved from http://www.who.int/nutrition/publications/moderate_malnutrition/MM_Background_paper3.pdf

Asiedu-Gyekye, I. J., Frimpong-Manso, S., Awortwe, C., Antwi, D. A., & Nyarko, A. K. (2014) Micro and macroelemental composition and safety evaluation of the nutraceutical *Moringa oleifera* leaves. *Journal of Toxicology*, 1-13. doi: 10.1155/2014/786979

Ayerza, R. (2012). Seed and oil yields of *Moringa oleifera* variety Periyakalum-1 introduced for oil production in four ecosystems of South America. *Industrial Crops and Products, 36*(1), 70-73. doi: 10.1016/j.indcrop.2011.08.008

Aziz, N., Jayasuriya, N., & Fan, L. (2015). Application of '*Moringa oleifera*' seeds and 'Musa cavendish' as coagulants for lead, nickel and cadmium removal from drinking water. In: *Asia Pacific Confederation of Chemical Engineering Congress 2015: APCChE 2015, incorporating CHEMECA 2015*. Melbourne: Engineers Australia, 1774-1781. Retrieved from https://researchbank.rmit.edu.au/view/rmit:35734

Beltrán-Heredia, J., Sánchez-Martín, J., & Barrado-Moreno, M. (2012a). Long-chain anionic surfractants in aqueous solution. Removal by *Moringa oleifera* coagulant. *Chemical Engineering Journal*, *180*(15), 128-136. doi: 10.1016/j.cej.2011.11.024

Beltrán-Heredia, J., Sánchez-Martín, J., Muñoz-Serrano, A., & Peres, J. A. (2012b). Towards overcoming TOC increase in waswater treated with *Moringa oleifera* seed extract. *Chemical Engineering Journal, 188*, 40-46. doi: 10.1016/j.cej.2012.02.003

Bichi, M. H. (2013). A review of the applications of *Moringa oleifera* seeds extracts in water treatment. *Civil and Enviromental Research*, *3*(8), 1-11. Retrieved from http://www.iiste.org/Journals/index.php/CER/article/view/6576/6722

Bijina, B., Chellappan, S., Krishna, J. G., Basheer, S. M., Elyas, K. K., BahkalI, A. H., & Chandrasekaran, M. (2011). Protease inhibitor from *Moringa oleifera* with potential for use as therapeutic drug and as seafood preservative. *Saudi Journal of Biological Sciences*, *18*(3), 273-281. doi: 10.1016/j.sjbs.2011.04.002

Borges-Teixeira, E. M., Barbieri-Carvalho, M. R., Neves, V. A., Apareci-Silva, M., & Arantes-Pereira, L. (2014). Chemical characteristics and fractionation of proteins from *Moringa oleifera* Lam. leaves. *Food Chemistry*, *147*, 51-54. doi: 10.1016/j.foodchem.2013.09.135

Budda, S., Butryee, C., Tuntipopipat, S., Rungsipipat, A., Wangnaithum, S., Lee, J. S., & Kupradinum, P. (2011). Suppresive effects of *Moringa oleifera* Lam pod against mouse colon carcinogenesis induced by azoxymethane and dextran sodium sulfate. *Asian Pacific Journal of Cancer Prevention, 12*(12), 3221-3228. Retrieved from http://www.apocpcontrol.org/paper_file/issue_abs/Volume12_No12/3221-28%20c11.8%20Budda.pdf

Caro, Y., Bustamante, D., Dihigo, L. E., & Ly, J. (2013). Harina de forraje de moringa (*Moringa oleifera*) como ingrediente en dietas para conejos de engorde. *Revista Computadorizada de Producción Porcina*, *20*(4), 218-222. Retrieved from http://www.iip.co.cu/RCPP/204/204_08YCaro.pdf

Cefali, L. C., Ataide, J. A., Moriel, P., Foglio, M. A., & Mazzola, P. G. (2016). Plant-based active photoprotectants for sunscreens, *Review. International Journal of Cosmetic Science, 38*, 346-353. doi: 10.1111/ics.12316

Chandrashekar, K. S., Thakur, A., & Prasanna, K. S. (2010). Phytochemical and pharmacological investigation of *Moringa oleifera. European Journal of Pharmacology*, *668*(1), 37. doi: 10.1016/j.ejphar.2011.09.280

Cheehpracha, S., Park, E. J., Yoshida, W. Y., Barit, C., Wall, M., Pezzuto, J. M., & Chang, L. C. (2010). Potential anti-inflammatory phenolic glycosides from medicinal plant *Moringa oleifera* fruits. *Bioorganic & Medicinal Chemistry*, *18*(17), 6598-6602. doi: 10.1016/j.bmc.2010.03.057

Chuang, P. H., Lee, C. W., Chou, J. Y., Murugan, M., Shieh, B. J., & Chen, H. M. (2007). Anti-fungal activity of crude extracts and essential oil of *Moringa oleifera* Lam. *Bioresource Technology*, *98*, 232-236. doi: 10.1016/j.biortech.2005.11.003

Correa-Araújo, L. C., Santos-Aguiar, J., Napoleão, T. H., Barreto-Mota, F. V., Souza-Barros, A. L., Moura, M. C., Cavalcanti-Coriolano, M., Barroso-Coelho, L. C. B., Gonçalves-Silva, T., & Guedes-Paiva, P. M. (2013).

Evaluation of cytotoxic and anti-inflammatory activities of extracts and lectins from *Moringa oleifera* seeds. *Plos One*, *8*(12), 1-15. doi: 10.1371/journal.pone.0081973

de Andrade-Luz, L., Cabral-Silva, M. C., da Silva-Ferreira, R., Aparecida-Santana, L., Silva-Lucca, R. A., Mentele, R., Vilela-Oliva, M. L., Guedes-Paiva, P. M., & Barroso-Coelho, L. C. B. (2013). Structural characterization of coagulant *Moringa oleifera* lecticin and its effect on hemostatic parameters. *International Journal of Biological Macromolecules, 58*, 31-36. doi: 10.1016/j.ijbiomac.2013.03.044

de Paula, H. M., de Oliveira-Ilha, M. S., & Santos-Andrade, L. (2016). Chemical coagulants and *Moringa oleifera* seed extract for treating concrete wastewater. *Acta Scientiarum Technology*, *38*(1), 57-64. doi: 10.4025/actascitechnol.v38i1.25699

de Melo, G. O., Malvar, D. C., Vanderlinde, F. A., Rocha, F. F., Andrade-Pires, P., Costa, E. A., de Matos, L. G., Kaiser, C. R., & Costa, S. S. (2009). Antinociceptive and anti-inflammatory kaempferol glycosides from *Sedum* dendroideum. *Journal of Ethnopharmacology*, *124*(2), 228-232. doi: 10.1016/j.jep.2009.04.024

Dhakar, R. C., Maurya, S. D., Pooniya, B. K., Bairwa, N., Gupta, M., & Sanwarmal. (2011). Moringa: The herbal gold to combat malnutrition. *Chronicles of Young Scientists, 2*(3), 119-125. Retrieved from http://www.cysonline.org/article.asp?issn=2229-5186;year=2011;volume=2;issue=3;spage=119;epage=125;aulast=Dhakar

Donkor, A. M., Kwame-Glover, R. L., Addae, D., & Kubi, K. A. (2013). Estimating the nutritional value of the leaves of *Moringa oleifera* on poultry. *Food and Nutrition Sciences*, *4*(11), 1077-1083. doi: 10.4236/fns.2013.411140

Dubey, K. D., Dora, J., Kumar, A., & Gulsan, R. K. (2013). A multipurpose Tree- *Moringa oleifera. International Journal of Pharmaceutical and Chemical sciences*, *2*(1), 415-423.

Fahey, W. (2005). *Moringa oleifera*. A review of the medical evidence for its nutritional, therapeutic and prophylactic properties Part I. *Trees for life Journal.*

Falasca, S., & Bernabé, M. A. (2008). Potenciales usos y delimitación del área de cultivo de *Moringa oleifera* en Argentina. *Revista Virtual REDESMA*, *3*, 1-16.

Freiberger, C. E., Vanderjagt, D. J., Pastuszyn, A., Glew, R. S., Mounkaila, G., Millson, M., & Glew, R. H. (1998). Nutrient content of the edible leaves of seven wild plants from Niger. *Plant Foods for Human Nutrition*, *53*, 57-69.

Föster, N., Ulrich, C., Schreiner, M., Müller, C. T., & Mewis, I. (2015). Development of a reliable extraction and quantification method of glucosinolates in *Moringa oleifera*. *Food Chemistry*, *166*, 456-464.

Galuppo, M., Giacoppo, S., Denicola, G. R., Iori, R., Navarra, M., Lombardo, G. E., Bramanti, P., & Mazzon, E. (2014). Antiinflammatory activity of glucomoringin isothicyanate in mouse model of experimental autoimmune encephalomyelitis. *Fitoterapia*, *95*, 160-174. doi: 10.1016/j.fitote.2014.03.018

Gami, B., & Parabia, F. (2011). Screening of methanol & acetone extract for antimicrobial activity of some medicinal plants species of Indian folklore. *International Journal Research in Pharmaceutical Sciences*, *2*(1), 69-75.

García, J., & Macias, M. (2014). Digestibilidad fecal y balance de nitrógeno en cerdos alimentados con diferentes niveles de harina de *Moringa oleifera* incluida en la dieta. *Livestock Research for Rural Development, 26*(12), Retrieved from http://www.lrrd.org/lrrd26/12/garc26215.html

Georgewill, O. A., Georgewill, U. O., & Nwankoala, R. N. P. (2010). Anti-inflamatory effects of *Moringa oleifera* Lam. extract in rats. *Asian Pacific Journal of Tropical Medicine*, *3*(2), 133-135. doi: 10.1016/S1995-7645(10)60052-1

Goja, A. M., & Osman, M. S. (2013). Preliminary Study on Efficacy of Leaves, Seeds and Bark Extracts of *Moringa oleifera* in Reducing Bacterial load in Water. *International Journal of Advanced Research*, *1*(4), 124-130.

Gomashe, A. V., Gulhane, P. A., Junghare, M. P., & Dhakate, N. A. (2014). Antimicrobial activity of Indian medicinal plants: *Moringa oleifera* and *Saraca indica*. *International Journal of Current Microbiology and Applied Science*, *3*(6), 161-169.

Hernández, E., García, A., López, M., Puls, J., Parajó, J. C., & Martín, C. (2013). Diluted sulphuric acid pretreatment and enzymatic hydrolysis of *Moringa oleifera* empty pods. *Industrial Crops and Products*, *44*, 227-231. doi: 10.1016/j.indcrop.2012.11.001

Howarth, M., & Benin, V. (2011). Theoretical investigation of a reported antibiotic from the "Miracle Tree" *Moringa oleifera*. *Computational and Theoretical Chemistry*, *965*, 196-201. doi: 10.1016/j.comptc.2011.01.045

Howladar, S. M. (2014). A novel *Moringa oleifera* leaf extract can mitigate the stress effects of salinity and cadmium in bean (*Phaseolus vulgaris* L.) plants. *Ecotoxicology and Environmental Safety, 100*, 69-75. doi: 10.1016/j.ecoenv.2013.11.022

Ijarotimi, O. S., Adeoti, O. A., & Ariyo, O. (2013). Comparative study on nutrient composition, phytochemical, and functional characteristics of raw, germinated, and fermented *Moringa oleifera* seed flour. *Food Science & Nutrition*, *1*(6), 452-463. doi: 10.1002/fsn3.70

Iqbal, S., & Bhager, M. I. (2006). Effect of season and production location on antioxidant activity of *Moringa oleifera* leaves grown in Pakistan. *Journal of Food Composition and Analysis, 19*, 544-551. doi: 10.1016/j.jfca.2005.05.001

Jeon, J. R., Kim, E. J., Kim, Y. M., Murugesam, K., Kim, J. H., & Chang, Y. S. (2009). Use of grape seed and its natural pholiphenol extracts as a natural organic coagulant for removal of cationic dyes. *Chemosphere, 77*, 1090-1098. doi: 10.1016/j.chemosphere.2009.08.036

Kalavathy, M. H., & Miranda, L. R. (2010). *Moringa oleifera* - A solid phase extractant for the removal of copper, nickel and zinc from aqueous solutions. *Chemical Engineering Journal*, *158*, 188-199. doi: 10.1016/j.cej.2009.12.039

Kana, J. R., Keambou, T. C., Raquel, S. J., Frederico, L., Mfopou, F. S., Mube, K. H., & Teguia, A. (2015). Effects of substituting soybean with *Moringa oleifera* meal in diets on laying and eggs quality characteristics of kabir chickens. *Journal of Animal Nutrition*, *1*(14), 1-6. Retrieved from http://animalnutrition.imedpub.com/archive.php

Karmakar, A., Karmakar, S., & Mukherjee, S. (2010). Properties of various plants and animals feedstocks for biodiesel production. *Bioresourse Technology*, *101*, 7201-7210. doi: 10.1016/j.biortech.2010.04.079

Kumar, V. (2013). *Moringa oleifera* or Sahijan -A Miracle plant of medicinal Value. In Tripathi, C. (Ed.*), Chemistry, Biochemistry and Ayurveda of Indian Medicinal Plants* (pp.140-144). India: International E-Publication.

Kumar, B., Kumar, S., & Kumar-Singh, A. (2015). Ayurvedic Medicine: A review on medicinal importance of shigru (*Moringa oleifera* Lam.) in Samhitas. *Indian Journal of Agriculture and allied Science*, *1*(3), 127-137.

Kumbhare, M. R., Guleha, V., & Sivakumar, T. (2012). Estimation of total phenolic content, cytotoxicity and *in-vitro* antioxidant activity of stem bark of *Moringa oleifera. Asian Pacific Journal of Tropical Disease*, *2*(2), 144-150. doi: 10.1016/S2222-1808(12)60033-4

Kumbhare, M. R., & Sivakumar, T. (2011). Anti-inflammatory and analgesic activity of stem bark of *Moringa oleifera.* Pharmacologyonline, *3*, 641-650.

Lijesh, K. P., & Malhotra, R. (2016). Reduction of turbidity of water using *Moringa oleifera*. *International Journal of Applied Engineering Research*, *11*(2), 1414-1423.

Lim, T. M. (2012). Moringa. In: *Edible medicinal plants and non-medicinal plants 3 (fruits)* (pp. 453-485). doi: 10/1007/978-94-007-2534-8-61

Liñan, T. F. (2010). *Moringa oleifera* El árbol de la nutrición. *Ciencia y salud vitual*, *2*(1), 130-138. Retrieved from http://www.curn.edu.co/journals/index.php/cienciaysalud/article/view/70

Luqman, S., Srivastava, S., Kumar, R., Maurya, A. K., & Chanda, D. (2012). Experimental assessment of *Moringa oleifera* leaf and fruit for its antistress, antioxidant, and scavenging potential using *in vitro* and *in vivo* assays. *Evidence-Based Complementary and Alternative Medicine,* 1-13. doi: 10.1155/2012/519084

Ly, J., Samkol, P., Phiny, C., Bustamante, D., & Caro, Y. (2016). Balance de nitrógeno (n) en cerdos alimentados con harina de follaje de *Moringa oleifera*. *Revista de BioCiencias*, *3*(4), 349-358. Retrieved from http://biociencias.uan.edu.mx/publicaciones/06-04/biociencias06-04-09.pdf

Maguro, L. O., & Lemmen, P. (2007). Phenolics of *Moringa oleifera* leaves. *Natural Products Research, 21*(1), 58-68.

Mahajan, S. G., Mali, R. G., & Mehta, A. A. (2007). Effect of *Moringa oleifera* Lam. seed extract on toluene diisocyanate-induced immune-mediated inflammatory Responses in Rats. *Journal of Immunotoxicology*, *4*, 85-96. doi: 10.1080/15476910701337472

Mahajan, S. G., & Mehta, A. A. (2010). Immunosupresive activity of ethanolic extracts of seeds of *Moringa oleifera* Lam. in experimental immune inflammation. *Journal of Ethnopharmacology*, *130*, 183-186. doi: 10.1016/j.jep.2010.04.024

Mahajan, S. G., & Mehta, A. A. (2011). Suppresion of ovalbumin-induced Th2-driven airway inflammation by β-sitosterol in a guinea pig model of asthma. *European Journal of Pharmacology*, *650*, 458-464. doi: 10.1016/j.ejphar.2010.09.075

Mahmood, K. T., Mugal, T., & Haq, I. U. (2010). *Moringa oleifera*: a natural gift-A review. *Journal of Pharmaceutical* Sciences & Research, 2(11), 775-781.

Makkar, H. P. S., & Becker, K. (1996). Nutrional value and whole and ethanol antinutritional components of extracted *Moringa oleifera* leaves. Animal Feed Science Technology, 63, 211-228.

McKnight, M., Allen, J., Waterman, J. T., Hurley, S., Idassi, J., & Minor, R. C. (2014). Moringa tea blocks acute lung inflammation induced by swine confinement dust through a mechanism involving TNF-α expression, C-Jun N-Terminal kinase activation and neutrophil regulation. American Journal of Immunology, 10(2), 73-87. doi: 10.3844/ajisp.2014.73.87

Melesse, A., Getye, Y., Berihum, K., & Banerjee, S. (2013). Effect of feeding graded levels of *moringa stenopetala* leaf meal on groth performance, carcass traits and some serum biochemical parameters of Koekoek chickens. *Livestock Science*, *157*, 498-505. doi: 10.1016/j.livsci.2013.08.012

Melesse, A., Steingass, H., Boguhn, J., Schollenberger, M., & Rodehutscord, M. (2012). Effects of elevation and season on nutrient composition of leaves and green pods of Moringa stenopetala and *Moringa oleifera*. *Agroforest Systems*, *86*, 505-518. doi: 10.1007/s10457-012-9514-8

Mendieta, A. B., Spörndly, R., Reyes, S. N., & Spörndly, E. (2011). Moringa *(Moringa oleifera)* leaf meal as a source of protein in locally produces concentrates for dairy cow fed low protein diets in tropical areas. *Livestock Science, 137*, 10-17. doi: 10.1016/j.livsci.2010.09.021

Mendieta, A. B., Spörndly, E., Reyes, S. N., Salmerón, M. F., & Halling, M. (2012). Biomass production and chemical composition of *Moringa oleifera* under different planting densities and levels of nitrogen fertilization. *Agroforest Systems, 87,* 81-92. doi: 10.1007/s10457-012-9525-5

Middha, S. K., Usha, T., Tripathi, P., Marathe, K. Y., Jain, T., Bhatt, B., Masurkar, Y. P., & Pande, V. (2012). An *In vitro* studies on indigenous ayurvedic plants, having hypoglycemic activity. *Asian Pacific Journal of Tropical Disease*, *2*(1), S46-S49.

Mishra, G., Singh, P., Verma, S., Kumar, S., Srivastav, S., Jha, K., & Khosa, R. L. (2011). Traditional uses, phytochemistry and pharmacological properties of *Moringa oleifera* plant: An overview. *Der Pharmacia Lettre, 3*(2), 141-164.

Mofijur, M., Masjuki, H. H., Kalam, M. A., Atabani, A. E., Fattah, I. M. R., & Mobarak, H. M. (2014). Comparative evaluation of performance and emission characteristics of *Moringa oleifera* and Palm oil based biodiesel in a diésel engine. Industrial Crops and Products, 53, 78-84. doi: 10.1016/j.indcrop.2013.12.011

Moyo, B., Oyedemi, S., Masika, P. J., & Muchenje, V. (2012). Poliphenolic content and antioxidant properties of *Moringa oleifera* leaf extracts and enzymatic activitiy of liver from goats suplemented with *Moringa oleifera* leaves/sunflower seed cake. Meat Science, 91, 441-447. doi: 10.1016/j.meatsci.2012.02.029

Muhammad, A. A., Pauzi, N. A. S., Arlselvan, P., Abas, F., & Fakurazi, S. (2013). In vitro wound healing potential and identification of bioactive compounds from *Moringa oleifera* Lam. BioMed. Research International, 10p. doi: 10.1155/2013/974580

Muthukumar, N., Naveena, B. M., Vaithiyanathan, S., Sen, A. R., & Sureshkumar, K. (2014). Effect of incorporation of *Moringa oleifera* leaves extract on quality of ground pork patties. Journal of Food Science & Technology, 51(11), 3172-3180. doi: 10.1007/s13197-012-0831-8

Muthuraman, G., & Sasikala, S. (2014). Removal of turbidity from drinking water using natural coagulants. Journal of Industrial and Engineering Chemistry, 20, 1727-1731. doi: 10.1016/j.jiec.2013.08.023

Nambiar, B., & Seshadri, S. (2001). Bioavailability trials of b-carotene from fresh and dehydrated drumstrick leaves (*Moringa oleifera*) in a rat model. Plant Foods for Human Nutrition, 56, 83-95. Retrieved from http://link.springer.com/article/10.1023%2FA%3A1008132503972

Ndong, M., Uehara, M., Katsumata, S. I., & Suzuki, K. (2007). Effects of oral administration of *Moringa oleifera* Lam. on glucose tolerance in Goto-Kakizaki and wistar rats. Journal of Clinical Biochemistry and Nutrition, 40(3), 229-233. doi: 10.3164/jcbn.40.229

Nkukwana, T. T., Muchenje, V., Pieterse, E., Mabusela, T. P., Hoffman, L. C., & Dzama, K. (2014a). Effect of *Moringa oleifera* leaf meal on growth performance, apparent digestibility, digestive organ size and carcass yield in broiled chickens. Livestock Science, 161, 139-146. doi: 10.1016/j.livsci.2014.01.001

Nkukwana T. T., Muchenje, V., Masika, P. J., Hoffman, L. C., Dzama, K., & Descalzo, A. M. (2014b). Fatty acid composition and oxidative stability of breast meat from broiler chickens supplemented with *Moringa oleifera* leaf meal over a period of refrigeration. Food Chemistry, 142, 255-261. doi: 10.1016/j.foodchem.2013.07.059

Nouman, W., Basra, S. M. A., Siddiqui, M. T., Yasmeen, A., Gull, T., & Alcayde, A. M. C. (2014). Potential of *Moringa oleifera* L. as livestock fodder crop: a review. *Turkish Journal of Agriculture and Forestry*, *38*, 1-14. doi: 10.3906/tar-1211-66

Ojiako, E. N. (2014). Phytochemical analysis and antimicrobial screening of *Moringa oleifera* extract. *The International Journal of Engineering and science*, *3*(3), 32-35.

Olson, M. E. (2010). Moringaceae: Drumstick Family. In Flora of North America Editorial Committee (Eds), Flora of North America North of Mexico (pp.167-169). Ney York and Oxford.

Olson, M. E., & Fahey, J. W. (2011). *Moringa oleifera*: un árbol multiusos para las zonas tropicales secas. Revista Mexicana de Biodiversidad, 82, 1071-1082.

Oluduro, O. A., Aderiye, B. I., Connolly, J. D., Akintayo, E. T., & Famurewa, O. (2010). Characterization and antimicrobial activity of 4-(b-D-Glucopyranosyl-1→4-a-L-rhamnopyranosyloxy)-benzyl thiocarboxamide; a novel bioactive compound from *Moringa oleifera* seed extract. Folia Microbiol, 55 (5), 422-426.

Omotesho, K. F., Sola, O. F E., Fayeye, T. R., Babatunde, R. O., Otunola, G. A., & Aliyu, T. H. (2013). The potential of Moringa tree for poverty alleviation and rural development: Review of evidences on usage and efficacy. International Journal of Development and Sustainability, 2(2), 799-813.

Oyeyinka, A. T., & Oyeyinka, S. A. (2016). *Moringa oleifera* as a food fortificant: Recent trends and prospects. *Journal of the Saudi Society of Agricultural Sciences,* doi: 10.1016/j.jssas.2016.02.002

Padilla, C., Fraga, N., & Suárez, M. (2012). Effect of the soaking time of moringa (*Moringa oleifera*) seeds on the germination and growth indicators of the plant. *Cuban Journal of Agricultural Science*, *46*(4), 419-421. Retrieved from http://www.ciencia-animal.org/cuban-journal-of-agricultural-science/articles/V46-N4-Y2012-P419-C-Padilla.pdf

Pakade, V., Cukrowskai, E., & Chimuka, L. (2013). Comparison of Antioxidant activity of *Moringa oleifera* and selected vegetables in South Africa. South African Journal of Science, 109(3/4), 2-5. doi: 10.1590/sajs.2013/1154

Paliwal, R., Sharma, V., & Pracheta. (2011). A review on Horse radish tree (*Moringa oleifera*): A multipurpose tree with high economic and commercial importance. Asian Journal of Biotechnology, 3(4), 317-328.

Panchal, M. A., Murti, K., Lambole, V., & Gajera, V. (2010) Pharmacological properties of *Moringa oleifera* Lam. A Review. Pharmacologyonline 2, 768-775.

Panda, S., Kar, A., Sharma, P., & Sharma, A. (2013). Cardioprotective potential of N, a-L-rhamnophyranosyl vincosamide, an indole alkaloid, isolated from the leaves of *Moringa oleifera* in isoproterenol induced cardiotoxic rats: in vitro studies. Bioorganic & Medicinal Chemistry Letters, 23, 959-962. doi: 10.1016/j.bmcl.2012.12.060

Parthiban, R., Vijayakumar, S., Prabhu, S., & Yabesh, J. G. E. M. (2016). Quantitative traditional knowledge of medicinal plants used to treat livestock diseases from Kudavasal taluk of Thiruvarur district, Tamil Nadu, India. Revista Brasileira de Farmacognosia, 26(1), 109-121. doi: 10.1016/j.bjp.2015.07.016

Pinheiro-Ferreira, P. M., Farias, D. F., de Abreu-Oliveira, J. T., & Urano-Carvalho, A. F. (2008). *Moringa oleifera*: bioactive compounds and nutritional potential. Revista de Nutrição Campinas, 21(4), 431-437.

Pontual, E. V., Carvalho, B. E., Bezerra, R. S., Coelho, L. C., Napoleão, T. H., & Paiva, P. M. (2012). Caseinolytic and milk-clothing activities from *Moringa oleifera* flowers. Food Chemistry, 135(3), 1848-1854. doi: 10.1016/j.foodchem.2012.06.087

Popoola, J. O., & Obeme, O. O. (2013). Local Knowledge, use pattern and geographical distribution of *Moringa oleifera* Lam. (Moringaseae) in Nigeria. Journal of Ethnopharmacology, 150, 682-691.

Prabhu, K., Murugan, K., Nareshkumar, A., Ramasubramanian, N., & Bragadeeswaran, S. (2011). Larvicidal and repellent potential of *Moringa oleifera* against malarial vector, Anopheles stephensi Liston (Insecta: Diptera: Culicidae). Asian Pacific Journal of Tropical Biomedicine, 124-129.

Pritchard, M., Craven, T., Mkandawire, T., Edmosnon, A. S., & O'neil, J. G. (2010). A comparison between *Moringa oleifera* and chemical coagulants in the purification of drinking water-An alternative sustainable solution for developing countries. *Physics and Chemistry of the Earth*, *35*, 798-805. doi: 10.1016/j.pce.2010.07.014

Promkun, C., Kupradinun, P., Tuntipopipat, S., & Butryee, C. (2010) Nutritive evaluation and effect of *Moringa oleifera* pod on clastogenic potential in the mouse. *Asian Pacific Journal of Cancer Prevention*, *11*(3), 627-632.

Rady, M. M., Varma, C. B., & Howladar, S. M. (2013). Common bean (*Phaseolus vulgaris* L.) seedlings overcome NaCl stress as a result of presoaking in *Moringa oleifera* leaf extract. *Scientia Horticulturae*, *162*, 63-70. doi: 10.1016/j.scienta.2013.07.046

Rahman, M., Hassan, M., Kalam, A., Atabani, A. E., Memon, L. A., & Rahman, S, M. A. (2014). Performance and emission analysis of *Jatropha curcas* and *Moringa oleifera* methyl ester fuel blends in a multi-cylinder diésel engine. *Journal of Clean Production*, *65*, 304-310. doi: 10.1016/j.jclepro.2013.08.034

Reddy, D. H. K., Harinath, Y., Seshaiah, K., & Reddy, A. V. R. (2010a). Biosorption of Pb (II) from aqueous solution using chemically modified *Moringa oleifera* tree leaves. *Chemical Engineering Journal*, *162*(2), 626-634. doi: 10.1016/j.cej.2010.06.010

Reddy, D. H. K., Seshaiah, K., Reddy, A. V. R., Rao, M. M., & Wang, M. C. (2010b). Biosorption of Pb^{2+} from aqueous solutions by *Moringa oleifera* bark: Equilibrium and kinetics studies. *Journal of Hazardous Materials*, *174*(1-3), 831-838. doi: 10.1016/j.jhazmat.2009.09.128

Reddy, D. H. K., Ramana, D. K. V., Seshaiah, K., & Reddy, A. V. R., (2011). Biosorption of Ni (II) from aqueous phase by *Moringa oleifera* bark, a low cost biosorbent. *Desalination*, 268, 150-157. doi: 10.1016/j.desal.2010.10.011

Rezende, D., Nishi, L., Coldebella, P. F., Silva, M. F., Vieira, M. F., Vieira, A. M. S, Bergamasco, R., & Fagundes-Klen, M. R. (2016). Groundwater nitrate contamination: Assessment and treatment using *Moringa oleifera* Lam. seed extracts and activated carbon filtration. *The Canadian Journal of Chemical Engineering, 94*(4), 725-732. doi: 10.1002/cjce.22442

Sabo-Mohamed, A. K., Long, K., Lai, O. M., Syed-Muhammad, S. K., & Mohd-Ghazali, H. (2007). Frying quality and stability of high-oleic *Moringa oleifera* seed oil in comparison with other vegetable oils. *Food Chemistry, 105*(4), 1382-1389. doi: 10.1016/j.foodchem.2007.05.013

Sanjay, P., & Dwivedi, K. N. (2015). Shingru (*Moringa oleifera* Lam.): A critical review. *International Journal of Ayurveda and Pharmaceutical Chemistry, 3*(1), 217-227.

Sánchez-Martín, J., Ghebremichael, K., & Beltrán-Heredia, J. (2010). Comparison of single step and two steps purified coagulants from *Moringa oleifera* seed for turbidity and DOC removal. *Bioresource Technology, 101*(15), 6259-6261. doi: 10.1016/j.biortech.2010.02.072

Sashidhara, K. V., Rosaiah, J. N., Tyagi, E., Shukla, R., Raghubir, R., & Rajendran, S. M. (2009). Rare dipeptide and urea derivatives from roots of *Moringa oleifera* as potential anti-inflammatory and nociceptive agents. *European Journal of Medicinal Chemistry*, *44*(1), 432-436. doi: 10.1016/j.ejmerch.2007.12.018

Sasikala, S., & Muthuraman, G. (2015). Reduction of Chemical oxygen demand (COD) in stabilization of pond water by various activated carbons. *International Journal of ChemTech Research, 7*(7), 2924-2928.

Satish, A., Kumar, R. P., Rakshith, D., Satish, S., & Ahmed, F. (2012). Antimutagenic and antioxidant activity of *Ficus benghalensis* stem bark and *Moringa oleifera* root extract. *International Journal of Chemical and Analytical Science*, *4*, 45-48. doi: 10.1016/j.ijcas.2013.03.008

Shanker, K., Gupta, M. M., Srivastava, S. K., Bawankule, D. U., Pal, A., & Khanuja, S. P. S. (2007). Determination of bioactive nitrile glycoside(s) in drumstick (*Moringa oleifera*) by reverse phase HPLC. *Food Chemistry, 105*(1), 376-382. doi: 10.1016/j.foodchem.2006.12.034

Sharma, B. K., Rashid, U., Anwar, F., & Erhan, S. Z. (2009). Lubricant properties of *Moringa* oil using thermal and tribological techniques. *Journal of Thermal Analysis and Calorimetry*, *96*(3), 999-1008. doi: 10.1007/s10973-009-0066-8

Singh, B. N., Singh, B. R., Singh, R. L., Prakash, D., Dhakarey, R., Upadhyay, G., & Singh, H. B. (2009). Oxidative DNA damage protective activity, antioxidant and anti-quorum sensing potentials of *Moringa oleifera*. *Food and Chemical Toxicity, 47*(6), 1109-1116. doi: 10.1016/j.fct.2009.01.034

Singh, N. (2012a). Panchakarma: Cleaning and rejuvenation therapy for curing the diseases. *Journal of Pharmacognosy and Phytochemistry*, *1*(2), 1-9.

Singh, G. P., Garg, R., Bhardwaj, S., & Sharma, S. K. (2012b). Anti-inflammatory evaluation of leaf extract of *Moringa oleifera. Journal of Pharmaceutical and Scientific Innovation*, *1*(1), 22-24.

Singh, R. S. G., Negi, P. S., & Radha, C. (2013). Phenolic composition, antioxidant and antimicrobial activities of free and bound phenolic extracts of *Moringa oleifera* seed flour. *Journal of Functional Foods*, *5*(4), 1883-1891. doi: 10.1016/j.jff.2013.09.009

Soliva, C. R., Kreuzer, M., Foidl, N., Foidl, G., Machmüller, A., & Hess, H. D. (2005). Feeding value of whole and extracted *Moringa oleifera* leaves for rumiants and their effects on rumial fermentation *in vitro*. *Animal*

Feed Science and Technology, *118*(1-2), 47-62. doi: 10.1016/j.anifeedsci.2004.10.005

Suhartini, S., Hidayat, N., & Rosaliana, E. (2013). Influence of powdered *Moringa oleifera* seeds and natural filter media on the characteristics of tapioca starch wastewater. *International Journal Of Recycling of Organic Waste in Agriculture*, *2*(12), 11. Retrieved from http://www.ijrowa.com/content/2/1/12al 2013

Sulaiman, M. R., Zakaria, Z. A., Bujarimin, A. S., Somchit, M. N., Israf, D. A., & Moin, S. (2008). Evaluation of *Moringa oleifera* aqueous extract for antinociceptive and anti-inflammatory activities in animal models. *Pharmaceutical Biology*, *46*(12), 838–845. doi: 10.1080/13880200802366710

Sultana, B., & Anwar, F. (2008). Flavonols (kaempferol, quercetin, myricetin) contents of selected fruits, vegetables and medicinal plants. *Food Chemistry*, *108*, 879-884. doi: 10.1016/j.foodchem.2007.11.053

Talreja, T. (2010). Screening of crude extract of flavonoids of *Moringa oleifera* against bacteria and fungal pathogen. *Journal of Phytology*, *2*(11), 31-35.

Tavengwa, N. T., Cukrowska, E., & Chimuka, L. (2016). Application of raw and biochared *Moringa oleifera* seed powder for the removal of nitrobenzene from aqueous solutions. *Desalination and Water Treatment*. doi: 10.1080/19443994.2016.1151381

Tiamiyu, L. O., Okomoda, V. T., & Aonde, A. (2016). Growth performance of *Oreochromis niloticus* fingerlings fed *Moringa oleifera* leaf as replacement for soybean meal. *Journal of Aquaculture Engineering and Fisheries Research, 2*(2), 61-66. doi: 10.3153/JAEFR16008

Torres, A. W., Méndez, G. M., Durán, G. R., Boulogne, I., & Germosén, R. L. (2015). Medicinal plant knowledge in Caribean Basin: a comparative study of Afrocaribbean, Amerindian and Mestizo communities. *Journal of Ethnobiology and Ethnomedicine, 11*(18). doi: 10.1186/s13002-015-0008-4

Urmi, K. F., Masum, N. H., Zulfiker, A. H., Hossain, K., & Hamid, K. (2012). Comparative anti-microbial activity and brine shrimp lethality bioassays of different parts of the plant *Moringa oleifera* Lam. *Journal of Applied Pharmaceutical Science, 2*(2), 085-088. doi: 10.7324/JAPS.2012.21216

Verma, A. R., Vijayakumar, M., Mathela, C. S., & Rao, C. (2009). *In vitro* and *in vivo* antioxidant properties of different fractions of *Moringa oleifera* leaves. *Food and Chemical Toxicology*, *47*(9), 2196-2201. doi: 10.1016/j.fct.2009.06.005

Verma, K. (2014). An ethnobotanical study of plants used for the treatment of livestock diseases in Tikamgarh District of Bundelkhand, Central India. *Asian Pacific Journal of Tropical Biomedicine, 4*(1), 460-467. doi: 10.12980/APJTB.4.2014C1067

Vongsak, B., Sithisarn, P., & Gritsanapan, W. (2013) Simultaneous determination of crypto-chlorogenic acid, isoquercetin, and astragalin contents in *Moringa oleifera* leaf extracts by TLC-densitometric method. *Evidence-Based Complementary and Alternative Medicine*, 1-7. doi: 10.1155/2013/917609

Waterman, C., Cheng, D. M., Rojas-Silva, P., Poulev, A., Dreifus, J., Lila, M. A., & Raskin, I. (2014). Stable, water extractable isothiocyanates from *Moringa oleifera* leaves attenuate inflammation in vitro. Phytochemistry, 103, 114-122. doi: 10.1016/j.phytochem.2014.03.028

Yameogo, C. W., Bengaly, M. D., Savadogo, A., Nikiema, P. A., & Traore, S. A. (2011). Determination of chemical composition and nutritional values of *Moringa oleifera* leaves. Pakistan Journal of Nutrition, 10(3), 264-268. Retrievedd from http://docsdrive.com/pdfs/ansinet/pjn/2011/264-268.pdf

Younus, I., Siddiq, A., Assad, T., Baddar, S., Jameel, S., & Ashraf, M. (2015). Screening antiviral activity of Moringa oliefera L. leaves against foot and mouth disease virus. Global Veterinaria 15(4), 409-413. doi: 10.5829/idosi.gv.2015.15.04.10116

Yousaf, M., Bukhhari, S. A. A., Atiq, M., Zaman, Z., Ibrahim, M., Sandhua, S. E., Talib, F., Younas, M., Shafiq, M., Nasira, F., Mubeen, I., & Chatha, M. U. (2015). Management of late blight of tomato through application of different plant exreacts. Pakistan Journal of Phytopathology, 27(2), 169-174.

Zayed, M. S. (2012). Improvement of growth and nutritional quality of *Moringa oleifera* using different biofertilizer. Annals of Agricultural Science, 57(1), 53-62. doi: 10.1016/j.aoas.2012.03.004

Zhao, S., & Zhang, D. (2013) Supercritical fluid extraction and characterization of *Moringa oleifera* leaves oil. *Separation and Purification Technology*, *118*, 497-502. doi: 10.1016/j.seppur.2013.07.046