

# Ethanopharmacology, Phytochemistry, Pharmacology and Toxicology of Moringaceae Family: A Review

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## ABSTRACT

Moringaceae family are used extensively in source of medicine, food, cosmetic oil, water purification and forage for livestock. Active compounds of natural ingredients need to be extensively explored to get their properties. The family Moringaceae is containing around 33 different species, only 13 species from these 33 species were documented. The 13 species of Moringaceae family are dicotyledonous tropical and sub-tropical flowering trees fit into three main categories that reflect life form and geography are slender trees, bottle trees and trees, shrubs and herbs of north eastern of Africa. The aim of this review was to provide an outline of Moringaceae species profiles, ethanopharmacology, pharmacological compound, phytochemistry and their toxicological activity. The method used to collect literature is the Science Direct, PubMed and Google Scholar search engines with keywords. Most important bioactive phytochemical constituents of these species are essential oils, flavonoids, alkaloids, tannins, terpenoid, phenolic

compounds, saponins and many more. Many studies showed that Moringaceae has efficacy as an antibacterial and antifungal properties; anti-malarial properties; anti-inflammatory and immunomodulatory properties; antiulcer properties; anticancer properties; hypoglycemic properties; hypolipidemic properties; hepato and kidney Protective properties; antioxidant properties; heart and circulatory energizers properties; antiepileptic properties; antispasmodic properties; antihypertensive properties. Further research needs to be done to make pharmaceutical preparations in the form of patent drugs with appropriate therapeutic doses for the betterment of human health.

**Keywords:** Moringaceae, Ethanopharmacology, Phytochemistry, Pharmacology, Toxicology, *Moringa oleifera*

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## INTRODUCTION

The Moringaceae family are dicotyledonous tropical and sub-tropical flowering trees which are used widely in source of medicine, food, cosmetic oil, water purification and forage for livestock (Berushka P and Himansu B, 2012). Different parts of trees have many therapeutic uses, pharmacological activities, sources of numerous active medicinal compounds. The family Moringaceae is containing around 33 different species, only 13 species from these 33 species were documented from old-world tropics (Maberley DJ, 1987). The 13 species of Moringaceae family are dicotyledonous tropical and sub-tropical flowering trees fit into three main categories that reflect life form and geography are slender trees, bottle trees and trees, shrubs and herbs of north eastern of Africa. The *M. oleifera* and *M. concanensis* are slender trees indigenous to India; *M. peregrina* indigenous to Red sea and Horn of Africa. The bottle trees are *M. stenopetala* indigenous to Kenya and Ethiopia; *M. hildebrandii* and *M. drouhardii* indigenous to Madagascar; *M. ovalifolia* indigenous to Namibia and Angola. The *M. arborea* trees, shrubs and herbs are indigenous to north eastern of Africa and Kenya; *M. pygmaea* indigenous to Somalia; *M. borziana*, indigenous to Somalia and Kenya; *M. rivae* indigenous to Kenya and Ethiopia; *M. ruspoliana* indigenous to Ethiopia, *M. longituba* indigenous to Kenya, Ethiopia and Somalia (Olson ME, 2002; Olson ME, 1999).

World Health Organization (WHO) and Pan American Health Organization (PAHO) define the "a medicinal plant" is (1) any natural plant or more of its parts contains chemical constituents or substances that can used in order to prevent, relieve or cure a disease or to change physiological and pathological process, or (2) any natural plant employed as a source of medicinal compounds/drugs or their precursors (Taiga A and Friday E, 2009; Arias TD, 1999). As per the World Health Organization (WHO) approximate that 4 Billion people, 80% of the world's population,

currently use plant-based natural medicine for their primary health care issues or to maintain health wellbeing (Owolabi MA, et al., 2007). The term "herbal drug" means the part/parts of a plant (leaves, roots, seeds, barks, flowers, stems, etc.) used for formulating herbal drugs and preparing its medicated formulations. The world is enriched with natural and exclusive sources of herbal and medicinal plants. In the last few years bio-friendly, eco-friendly, relatively safe, less side effects and cost-effective, plant based natural medicines have moved from the fringe to the conventional with the increased research in the field of traditional medicine therefore a tremendous growth in the field of herbal or ayurvedic medicine (Sen S, et al., 2011). In developing and developed countries herbal medicine are getting more popular because of its natural origin and lower side effects (Brahmachari UN, 2001). Now a day's traditional practitioner of developing and developed countries relies on medicinal plants in order to cure some health problem, disease and their health care needs on large number of populations. Because of their low side effects and natural origin natural herbal medicines and traditional practice have often continued their popularity for historical and cultural reasons compare to modern medicines. Herbal plants have been a used as source of medicinal agents for thousands of years and a remarkable number of modern therapeutic drugs have been isolated from natural sources as well as food supplements, nutraceuticals, folk medicines. Similarly, pharmaceutical intermediates and precursor for modern synthetic drugs has also been isolated from herbal plant or natural sources. Several isolations and extracted herbal natural constituents were uses as therapeutic agents in traditional medicine. An herbal medicine preparation or phytopharmaceutical formulations or both are manufactured medicine obtained exclusively from natural plants (such as aerial and non-aerial parts, essential oil, juices and resins), or in the crude state (Rates SM, 2001).

## LITERATURE REVIEW

Now a days herbal or ayurvedic medicinal plants are getting more popular than ever because they have potential innumerable benefits and have lesser adverse effects compare to allopathic or synthetic medicine to society or definitely to all mankind, especially in the line of pharmacological and therapeutic area. The bioactive phytochemical constituents of these herbal plants have more medicinal value which produces definite pharmacological action on the human body (Afolabi CA, et al., 2007). Natural plant contain most important bioactive phytochemical constituents are essential oils, alkaloids, flavonoids, saponins, tannins, terpenoid, phenolic compounds and several more (Edeoga HO, et al., 2005). Still, add a note of caution stating that herbal remedies are effective under appropriate medical supervision or traditional practitioner and without side-effects but require a longer time for treatment of health problem. The medicinally active component and secondary metabolite are differing in quality and quantity for an herbal plant species because they are growing in different locations and regions (Prajapati D, et al., 2004). The market value of such natural plants depends on their active content and medicinal use rather than merely their flourishing growth. As consider more than 70,000 species of the natural plant kingdom have been used as ayurvedic herbal medicine at one time or other (Purohit S and Vyas S, 2004).

Moringceae is one of the family whose different species have not been investigated completely in spite of and the gigantic reports concerning the different parts i.e., seeds, roots, stem, bark, leaves of a few species have a medicinal properties such as, for example, antibacterial and antifungal properties; anti-malarial properties; anti-inflammatory and immunomodulatory properties; antiulcer properties; anticancer properties; hypoglycaemic properties; hypolipidemic properties; hepato and kidney protective properties; antioxidant properties; heart and circulatory energizers properties; antiepileptic properties; antispasmodic properties; antihypertensive properties. Different species also being used for treatment of various ailments in the indigenous system of medicine (Jayabharathi M and Chitra M, 2011; Fahey JW, 2005; Morton JF, 1991; Cáceres A, et al., 1992; Pal SK, et al., 1995; Eilert U, et al., 1981; Guevara AP, et al., 1999; Buraimoh AA, et al., 2011; El-Alfy TS, et al., 2011; Anbazhakan S, et al., 2007).

The *Moringa Oleifera* and moringaceae family species is referenced in greater than 80 countries and its indigenous knowledge and use known in over 200 local languages. *Moringa* medicinal benefits and its cultivation has been increasing across Asia, Africa, Latin America, Greek, Roman, Egypt and many others for thousands of years with literatures dating as far back as 150 AD. The history of *Moringa* dates back to 150 BC, ancient Egyptians applied it topically to prevent skin infection while Indians use it for curing high blood pressure. Ancient Maurian warriors of India were given to *Moringa* leaves extract as Elixir formulation in the warfront. The elixir preparation drink was believed to add them extra energy and relieve them of the pain and stress suffered during war. In the Caribbean country, *Moringa* is used for the treatment of warts in Aruba and eye infections in Puerto Rico, where ancient kings and queens used *Moringa* leaf and fruit in their diet to wellness of mental awakening, healthy and glowing skin. Many other country health practitioners use moringaceae family plant for various health diseases to cure or prevent such as Senegal health practitioners prescribe it to treat weakness and dizziness and Nicaraguan health practitioners use *Moringa* buds to sooth headaches. The *Moringa* species are presently of widespread interest because of their outstanding economic potential (Arora DS, et al., 2013; Aaron K, 2022; Mahmood KT, et al., 2010).

Literature review shown that Bio prospecting of Moringaceae and medicinal importance of Moringaceae are published (Berushka P and Himansu B, 2012; Arora DS, et al., 2013). In both these article very less comprehen-

sive phytoconstituents and pharmacology of these Moringaceae family was given and extensive literature will be needed to establish the wide-ranging phytoconstituents and pharmacology of these and other Moringaceae species, and additional explore and exploit their pharmacological properties not overlooking to ascertain the safety and therapeutic use of the active phytoconstituents. This comprehensive review article has been collected and gathering information from the literature documenting the ethanopharmacology, phytochemistry, pharmacology and toxicology of Moringaceae species.

### Ethanopharmacology

As per the World Health Organization, traditional medicine comprise diverse health practices, knowledge, approaches and beliefs incorporating natural herbal plant, animal and/or mineral based medicines, spiritual therapies, manual techniques and exercises, given alone or in combination to maintain well-being, as well as to cure, diagnose or prevent disease or illness. The importance Moringaceae species was due to their wide variety of medicinal properties.

For the preparation of review article, the ethnopharmacology and ethnobotanical reports of *Moringa Oleifera* and moringaceae species were select with quantitative data and with prior attention to the frequency of citation for additional potential investigations. In the tropics and subtropics, *Moringa Oleifera* herbs are generally used in traditional medicine. Still, *Moringa Oleifera* re-presents only 7% of a moringaceae species of which the other species remains unexplored and underutilized. Researchers have mainly focused on the phytochemical constituents, medicinal properties and nutritional values of *Moringa Oleifera*; henceforth, there is very slight information, documentation or research done on the importance of the other species within the genus, which are similarly as important and valuable (Berushka P and Himansu B, 2012). Almost plant parts like leaves, seed etc. of this genus are used medicinal agents in human for the treatment or prevent variety of disorders. The major use of Moringaceae species are as Nutritional/Vitamin Supplement (Malnutrition), anti-malarial agent, Anti-hypertensive, Diabetes mellitus. A wide range of application in folk medicine of moringaceae plants belonging to this genus has been reported. The summary of ethnopharmacological data on Moringaceae found in the literature is shown in Table 1.

### Phytochemistry

Phytochemicals mens only those chemicals which may have an effect on health, or on color, smell, texture, or flavour of the plants, but are not essential by humans as vital nutrients (Fahey JW, 2005). Natural Plant produced chemical compounds means phytochemicals like glycosides, alkaloids, carotenoids, tannins, anthraquinones, flavonoids, anthocyanins, proanthocyanidins, polyphenol, phenolic acids, saponins, carbohydrates, phytosterols, vitamins, oxalates and phytates have been used in a wide variety of commercial constituents and industrial utilization such as cosmetics, water purifying agent, bio-based fuels, biosorbent and plastics as well as natural pigments and bioactive compounds. The continuous research focus on therapeutic use of phytochemicals is increasing day by day due to the harmful adverse effects of the synthetic medicinal compounds. Several research article and reports have been published about the phytochemical content of moringaceae species and reported to have numbers of phytochemical compounds. Following Table 2 represent the published research and review article of phytochemical compounds of moringaceae species.

The Phytochemical constituents in *M. oleifera* leaves, seed, fruits diverges somewhat with the topographical and climatic conditions under which the plant was grown-up, as well as with the processing methods for the collection of leaves (Coppin J, 2008; Mukunzi D, et al., 2011).

Table 1: Ethanopharmacology use of Moringaceae

| Plant name                | Part(s) used       | Country                       | Medicinal use                                                                                                                                                           | References                                           |
|---------------------------|--------------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| <i>M. oleifera</i>        | Leaves             | Thai                          | Hypolipidaemic and Antiatherosclerotic activities                                                                                                                       | Chumark P, et al., 2008                              |
|                           | Leaves             | Ugandan rural                 | Vitamin supplement (Malnutrition), Malaria/Fever, Anti-hypertensive, Diabetes mellitus, Lactation enhancer, Impotence, HIV/AIDS-related symptoms, External sores/ulcers | Kasolo JN, et al., 2010                              |
|                           | Leaves             | India                         | Anti-Diabetic agent (Type II)                                                                                                                                           | William F, et al., 1993; Ghiridhari VV, et al., 2011 |
|                           | Leaves             | Gujarat, India                | Anti dyslipidemic agent                                                                                                                                                 | Nambiar VS, et al., 2010                             |
|                           | Leaves             | Andhra Pradesh, India         | Anti dyslipidemic agent, Anti Diabetic agent (Type II)                                                                                                                  | Kumari DJ, 2010                                      |
|                           | Leaves             | South Africa                  | Antiproliferative properties (Lung Cancer)                                                                                                                              | Tiloke C, et al., 2013                               |
|                           | Leaves             | African Country               | Nutritional Supplement                                                                                                                                                  | Fuglie LJ, 2005                                      |
|                           | Leaves/ Root/ Stem | Zimbabwe                      | Boost the immune system in HIV positive patient                                                                                                                         | Monera TG and Maponga CC, 2012                       |
|                           | Seed and leaf      | Guatemala                     | Treatment of infectious skin and mucosal diseases                                                                                                                       | Rockwood JL, et al., 2013                            |
|                           | Leaves             | Nigeria                       | Malaria, Stomach pain, High blood pressure, Stroke, Rheumatism, Chronic sickness (HIV infection)                                                                        | Popoola JO and Obembe OO, 2013                       |
|                           | Seed               | Nigeria                       | Ease stomach pain, Ulcer, Joint pain                                                                                                                                    | Popoola JO and Obembe OO, 2013                       |
|                           | Bark               | Nigeria                       | Hypertension, Diabetes, Potent against snake and scorpion bite                                                                                                          | Popoola JO and Obembe OO, 2013                       |
|                           | Root               | Nigeria                       | Nervous disorder, Hysteria, pain, Pile, toothache, Sex enhancer                                                                                                         | Popoola JO and Obembe OO, 2013                       |
|                           | Leaves             | Kerala, India                 | Cancer, Eye cooling, Cold, cough                                                                                                                                        | Yabesh JM, et al., 2014                              |
|                           | Bark               | Kerala, India                 | Uterine disorder, Female contraception                                                                                                                                  | Yabesh JM, et al., 2014                              |
|                           | Seed               | Kerala, India                 | Cooling agent                                                                                                                                                           | Yabesh JM, et al., 2014                              |
|                           | Flower             | Kerala, India                 | Sperm production                                                                                                                                                        | Yabesh JM, et al., 2014                              |
| <i>M. stenopetaloides</i> | Leaves, Roots      | Southern Ethiopia             | Antiplasmodial activity                                                                                                                                                 | Dori GU, et al., 2010                                |
|                           | Leaves             | Konso, South-Western Ethiopia | Colds and anaemia, Digestion problems and dysentery, Malaria                                                                                                            | Demeulenaere E, 2001; Seid MA, 2013                  |
|                           | Roots              | Kenya                         | Epilepsy                                                                                                                                                                | Demeulenaere E, 2001; Seid MA, 2013                  |
|                           | Leaves, Roots      | Ethiopia                      | To treat Malaria, Hypertension, Stomach disorders, Asthma and Diabetes                                                                                                  | Mekonnen Y, et al., 1999; Bosch CH, 2004             |
|                           | Leaves             | Ethiopia                      | To treat hypertension and diabetes                                                                                                                                      | Jahn SA, 1991                                        |
|                           | Leaves             | Southern Ethiopia             | The retained placenta in women                                                                                                                                          | Mekonnen Y, 2002                                     |
|                           | Roots              | Southern Ethiopia             | Antileishmanial agent                                                                                                                                                   | Mekonnen Y and Gessesse A, 1998                      |

|                         |                       |                                               |                                                                                                                       |                                                                     |
|-------------------------|-----------------------|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| <i>M. peregrina</i>     | Leaves                | Somalia, Arabian Gulf                         | Treat headaches, fevers constipation, burns, various pains                                                            | Boulos L, 2000; Miller AG and Morris M, 1990                        |
|                         | Leaves and Roots      | Arabian Gulf                                  | Treat malaria, stomach disorders, hypertension, asthma and diabetes                                                   | Mekonnen Y, <i>et al.</i> , 1999; Elbatran SA, <i>et al.</i> , 2005 |
|                         | Leaves                | Somalia, Yemen to Jordan, Palestine and Syria | Anti-oxidant and wound healer                                                                                         | Nawash OS and Ahmad Al-S H, 2011                                    |
|                         | Aerial parts          |                                               | Malaria, Hypertension, Fever, Asthma and Diabetes                                                                     | Ayyari M, <i>et al.</i> , 2014                                      |
| <i>M. concanensis</i>   | Leaves                | Tamilnadu, India                              | Anti-fertility agent                                                                                                  | Subramanian N, 2009                                                 |
|                         | Root, Root bark       | Tamilnadu, India                              | Paralysis, Epilepsy, Rheumatism, Fainting and Abscess                                                                 | Jayabharathi M and Chitra M, 2011                                   |
|                         | Stem bark             | Tamilnadu, India                              | Headaches and Dental problems                                                                                         | Anbazhakan S, <i>et al.</i> , 2007                                  |
|                         | Leaves                | Tamilnadu, India                              | Menstrual pain, constipation, jaundice, diabetes and skin tumours and to reduce cholesterol levels and blood pressure | Anbazhakan S, <i>et al.</i> , 2007                                  |
|                         | Flowers               | Tamilnadu, India                              | Thyroid problems and leucorrhoea                                                                                      | Anbazhakan S, <i>et al.</i> , 2007                                  |
|                         | Fruits                | Tamilnadu, India                              | Curing liver and spleen diseases and joint pains                                                                      | Jayabharathi M and Chitra M, 2011                                   |
|                         | Dried seeds           | Tamilnadu, India                              | In the treatment of goitre, venereal affection, glycosuria and lipid disorders                                        | Shantanu K, <i>et al.</i> , 2010                                    |
| <i>Moringa riveae</i>   | Leave                 | Pakistan                                      | Treat weakness of the thigh and calf muscles                                                                          | Berushka P, Himansu B, 2012                                         |
|                         | Gum                   | Pakistan                                      | Arthritis                                                                                                             |                                                                     |
| <i>M. arborea</i>       |                       |                                               | No data available                                                                                                     |                                                                     |
| <i>M. borziana</i>      | Root powder           | Kenya and Somalia                             | Treat abdominal pain and haemorrhoids                                                                                 | Berushka P, Himansu B, 2012                                         |
| <i>M. pygmaea</i>       | Tubers                | Somalia                                       | Eliminate stomach parasites and treat intestine diseases                                                              | Thulin M, 2012                                                      |
| <i>M. ruspoliana</i>    |                       | Wajir, Moyale, Mandera districts of Kenya     | Abdominal pains, eye and throat infections, sexually transmitted diseases in humans                                   | Odee DW, <i>et al.</i> , 2001                                       |
| <i>M. hildebrandtii</i> |                       |                                               | No data available                                                                                                     |                                                                     |
| <i>M. ovalifolia</i>    |                       |                                               | No data available                                                                                                     |                                                                     |
| <i>M. drouhardii</i>    | Wood and Scented bark | South-Western Madagascar                      | Treatment of coughs and colds                                                                                         | Berushka P, Himansu B, 2012                                         |
| <i>M. longituba</i>     |                       | Wajir, Moyale, Mandera districts of Kenya     | Abdominal pains, eye and throat infections, sexually transmitted diseases in humans                                   | Odee DW, <i>et al.</i> , 2001                                       |

Table 2: Phytochemical compounds isolated from Moringaceae

| Plant name         | Part(s) used      | Extract                                   | Compounds                                                                                                                                                                                                                                                                                              | Reference                                                           |
|--------------------|-------------------|-------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| <i>M. oleifera</i> | Stem bark         |                                           | Alkaloids, namely moringine and morninginine                                                                                                                                                                                                                                                           | Kerharo PJ, 1969                                                    |
|                    | Stem and Bark     |                                           | Vanillin, sitosterol, $\beta$ -sitostenone, 4-hydroxymellin and octacosanoic acid                                                                                                                                                                                                                      | Faizi S, et al., 1994; Saluja MP, et al., 1978                      |
|                    | Whole-gum exudate |                                           | L-arabinose, L-galactose, glucuronic acid, and L-rhamnose, L-mannose and xylose                                                                                                                                                                                                                        | Bhattacharya SB, et al., 1982                                       |
|                    |                   |                                           | Leucoanthocyanin                                                                                                                                                                                                                                                                                       | Khare GC, et al., 1997                                              |
|                    | Flowers           |                                           | Amino acids, Sucrose, D-glucose, traces of alkaloids, wax, quercetin and Kaempferol                                                                                                                                                                                                                    | Ruckmani K, et al., 1998                                            |
|                    |                   |                                           | Natural sugar, D-mannose, D-glucose, D-galactose, D-Glucuronic acid, Ascorbic acid                                                                                                                                                                                                                     | Pramanik A, Islam SS, 1998                                          |
|                    | Pods              | Acetate phase of the ethanol extract      | Thiocarbamate and Isothiocyanate glycosides                                                                                                                                                                                                                                                            | Faizi S, et al., 1994; Faizi S, et al., 1998; Faizi S, et al., 1995 |
|                    | Fruits            |                                           | Cytokinins                                                                                                                                                                                                                                                                                             | Nagar PK, et al., 1982                                              |
|                    | Fruits            | Ethyl acetate extract                     | 4-[(2'-O-acetyl-alpha-l-rhamnosyloxy) benzyl]isothiocyanate, 4-[(3'-O-acetyl-alpha-l-rhamnosyloxy)benzyl] isothiocyanate, and S-methyl-N-{4-[(alpha-l-rhamnosyloxy)benzyl]} thiocarbamate,                                                                                                             | Cheenpracha S, et al., 2010                                         |
|                    | Leaves            | Water, aqueous methanol, Ethanol extracts | Flavonoid pigments such as quercetin, kaempferol, rhamnetin, isoquercitrin and kaempferitrin                                                                                                                                                                                                           | Faizi S, et al., 1994; Siddhuraju P and Becker K, 2003              |
|                    | Leaves            | Ethanol extracted                         | Ascorbic acid, oestrogenic substances and $\beta$ -sitosterol, iron, calcium, phosphorus, copper, vitamins A, B and C, $\alpha$ -tocopherol, riboflavin, nicotinic acid, folic acid, pyridoxine, $\beta$ -carotene, protein, and essential amino acids such as methionine, cystine, tryptophan, lysine | Makkar HA and Becker K, 1996                                        |
|                    | Leaves            |                                           | Vitamin A, Vitamin B <sub>1</sub> -Thiamine, Vitamin B <sub>2</sub> -Riboflavin, Vitamin B <sub>3</sub> -Niacin                                                                                                                                                                                        | Ramachandran C, et al., 1980; Price M, 1985                         |
|                    |                   |                                           | Vitamin C-Ascorbic acid                                                                                                                                                                                                                                                                                | Pallavi J and Dipika M, 2010                                        |
|                    |                   |                                           | Vitamin E-Tocopherol                                                                                                                                                                                                                                                                                   | Moyo B, et al., 2011                                                |
|                    |                   |                                           | Lutein, $\beta$ -carotene, Polyphenols, Caffeic acid, o-Coumaric acid, p-Coumaric acid                                                                                                                                                                                                                 |                                                                     |
|                    |                   |                                           | Gentistic acid, Sinapic acid, Syringic acid Flavonoids, Epicatechin                                                                                                                                                                                                                                    | Min Z, et al., 2011                                                 |
|                    |                   |                                           | Caffeic acid, Chlorogenic acid, Ellagic acid, Ferulic acid, Gallic acid, Myricetin, Rutin                                                                                                                                                                                                              | Prakash D, et al., 2007; Verma AR, et al., 2009                     |
| Root, Seed, Leaves |                   |                                           | 4-( $\alpha$ -L-rhamnopyranosyloxy)-benzylglucosinolate and Benzylglucosinolate                                                                                                                                                                                                                        | Bennett RN, et al., 2003                                            |
| Leaves             |                   |                                           | Quercetin-3-O-glucoside, quercetin-3-O-(6"-malonyl-glucoside), kaempferol-3-O-glucoside, kaempferol-3-O-(6"-malonyl-glucoside), 3-caffeoylequinic acid and 5-caffeoylequinic acid                                                                                                                      |                                                                     |
| Leaves             |                   |                                           | $\alpha$ -l-Rhamnosides of 4-hydroxy-benzyl compounds with nitrile, carbamate, and thiocarbamate groups                                                                                                                                                                                                |                                                                     |

|  |                                         |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                             |
|--|-----------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
|  | Leaves                                  | Methanolic extract | flavonol glycosides such as kaempferide 3-O-(2",3"-diacetylglucoside), kaempferide 3-O-(2"-O-galloylrhamnoside), kaempferide 3-O-(2"-O-galloylrutinoside)-7-O-alpha-rhamnoside, kaempferol 3-O-(beta-glucosyl-(1→2))-alpha-rhamnosyl-(1→6)-beta-glucoside-7-O-alpha-rhamnoside and kaempferol 3-O-(alpha-rhamnosyl-(1→2))-(alpha-rhamnosyl-(1→4))-beta-glucoside-7-O-alpha-rhamnoside together with benzoic acid 4-O-beta-glucoside, benzoic acid 4-O-alpha-rhamnosyl-(1→2)-beta-glucoside and benzaldehyde 4-O-beta-glucoside, kaempferol 3-O-alpha-rhamnoside, kaempferol, syringic acid, gallic acid, rutin and quercetin 3-O-beta-glucoside | Verma AR, et al., 2009; Manguro LO and Lemmen P, 2007                                                       |
|  | Leaves                                  | Methanol extract   | Chlorogenic acid, rutin, quercetin glucoside, and kaempferol rhamnoglucoside                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Atawodi SE, et al., 2010                                                                                    |
|  | Seeds                                   |                    | 4-(α-L-rhamnopyranosyloxy) benzyl isothiocyanate, methyl N-4-(α-L-rhamnopyranosyloxy) benzyl carbamate (both known compounds), and 4-(β-D-glucopyranosyl-1→4-α-L-rhamnopyranosyloxy)-benzyl thiocarboxamide                                                                                                                                                                                                                                                                                                                                                                                                                                     | Oluduro OA, et al., 2010                                                                                    |
|  | Seeds                                   |                    | Crude Protein, Crude fat, Carbohydrate, essential amino acid lysine, threonine, valine, methionine, cysteine                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Oliveira JT, et al., 1999                                                                                   |
|  | Seeds                                   |                    | 2-propyl, 2-butyl and 2-methylpropyl isothiocyanate in addition to 5,5-dimethyl-oxazolidine-2-thione, 4-(4'-O-Acetyl-α-l-rhamnosyloxy)benzyl isothiocyanate,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Kær A, et al., 1979                                                                                         |
|  | Seeds                                   |                    | Vitamin E, Beta carotene, Vitamin A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Dahot MU and Memon AR, 1985                                                                                 |
|  | Seeds                                   | Methanol fractions | Methyl ester-hexadecanoic acid, L-(+)-Ascorbic acid 2, 6-dihexa-decanoate, Methyl ester-9-octadecenoic acid, Oleic acid, 9-octadecenamide, Phytol, 1,2-Benzene dicarboxylic acid, 1-Hexadecanol, 14-methyl-8-hexadecenal                                                                                                                                                                                                                                                                                                                                                                                                                        | Aja PM, et al., 2014                                                                                        |
|  | Seed                                    | Benzene            | Mono palmitic and di-oleic triglyceride                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Memon GM and Khatri LM, 1987                                                                                |
|  | Seed                                    | Ethanol extract    | Niazimin, Niazimin A, Niazimin B, Niazicin A and niazicin B, 3-O-(6'-O-oleoyl-β-D-glucopyranosyl)-β-sitosterol, β-sitosterol-3-O-β-D-glucopyranoside, niazirin, β-sitosterol and glycerol-1-(9-octadecanoate)                                                                                                                                                                                                                                                                                                                                                                                                                                   | Guevara AP, et al., 1999; Makkar HA and Becker K, 1996; Anwar F and Bhanger MI, 2003; Faizi S, et al., 1994 |
|  | Seed oil                                |                    | Oleic acid, Palmitic acid, Stearic acid, Behenic acid, Arachidic acid, Campesterol, Stigmasterol, α Sitosterol, β5-Avenasterol, Clerosterol, 24-methylene cholesterol, α7-campestanol and 28-isoavenasterol, α, β, γ-Tocopherols                                                                                                                                                                                                                                                                                                                                                                                                                | Anwar F and Bhanger MI, 2003; Lalas S and Tsaknis J, 2002                                                   |
|  | Seed and Root                           |                    | 4-(α-L-rhamnosyloxy)-benzylisothiocynate and benzylisothiocynate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Eilert U, et al., 1981                                                                                      |
|  | Seed oil                                |                    | Mono-unsaturated fatty acids: Omega-9 mono-unsaturated acids, (cis-9-octadecenoic (oleic acid), cis-11-eicosenoic acids), omega-7 mono-unsaturated acid (cis-11-octadecenoic acid (vaccenic acid))                                                                                                                                                                                                                                                                                                                                                                                                                                              | Vlahov G, et al., 2002                                                                                      |
|  | Root Barks                              | Chloroform extract | Deoxy niazimicine                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Nikkon F, et al., 2003                                                                                      |
|  | Roots                                   |                    | Aurantiamide acetate and 1,3-dibenzyl urea                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Sashidhara KV, et al., 2009                                                                                 |
|  | Stem, Roots, Flower, Pods, Seed, Leaves |                    | 4-O-(α-L-rhamnopyranosyloxy)-benzylglucosinolate (glucomoringin), Quercetin, Kaempferol, Isorhamnetin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                             |
|  | Stem                                    |                    | Caffeoylquinic acids                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Amaglo NK, et al., 2010                                                                                     |
|  | Roots                                   |                    | Benzylglucosinolate (glucotropaeolin)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                             |
|  | Flowers                                 |                    | 4-hydroxybenzylglucosinolate three mono-acetyl-rhamnose isomers, Caffeoylquinic acids                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                             |
|  | Leaves                                  |                    | 4-hydroxybenzylglucosinolate three mono-acetyl-rhamnose isomers, Caffeoylquinic acids,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                             |

|                       |                    |                                                                                                                                                                                             |                                                 |
|-----------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| <i>M. Stenopetala</i> | Root, seed, leaves | 4-( $\alpha$ -L-rhamnopyranosyloxy)-benzylglucosinolate and Benzylglucosinolate                                                                                                             | Bennett RN, et al., 2003                        |
|                       | Leaves             | Quercetin 3-O-rhamnoglucoside (rutin), 3-O-glucoside and 5-caffeoquinic acid                                                                                                                |                                                 |
|                       | Root, seed, leaves | Glucoconringiin and O-(rhamnopyranosyloxy)benzyl glucosinolate                                                                                                                              | Mekonnen Y and Dräger B, 2003                   |
|                       | Leaves             | Ethanol extract<br>Rutin, 4-(4'-O-acetyl-L-rhamnosyloxy)-benzylisothiocyanate and 4-(4'-O-acetyl-L-rhamnosyloxy)-benzaldehyde                                                               | Mekonen A and Gebreyesus T, 2000                |
|                       | Seeds              | Isothiocyanates, Benzyl isothiocyanate and Isobutyl isothiocyanate                                                                                                                          | Nibret E and Wink M, 2010                       |
|                       | Leaves             | Vitamin C, $\alpha$ and $\beta$ -Carotene, P-Cryptoxanthin, Zeaxanthin, Lutein, Retinol, Cynogenic glycoside                                                                                | Abuye C, et al., 2003                           |
|                       | Leaves             | Flavonoid: Quercetin; Total polyphenolic: Gallic acid; Condensed tannins: Catechin                                                                                                          | Toma A, et al., 2014                            |
|                       | Leaves             | Essential amino acids: Arginine, Cysteine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Valine                                                                        | Melesse A, 2011                                 |
|                       | Leaves             | The presence of alkaloids, saponins, polyphenols, flavonoids, coumarins, terpenoids, anthraquinones, tannins, phytosterols and cardiac glycosides                                           | Geleta B, et al., 2016                          |
|                       | Leaves             | Rutin, 4-(4'-O-acetyl-L-rhamnosyloxy)-benzylisothiocyanate and 4-(4'-O-acetyl-L-rhamnosyloxy)-benzaldehyde                                                                                  | Mekonen A and Gebreyesus T, 2000                |
| Seed                  | Roots              | 1,3-dilinoleoyl-2-olein and 1,3-dioleoyl-2-linolein                                                                                                                                         | Bekele B, et al., 2013                          |
|                       | Seed               | Unsaturated fatty acids: Oleic acid                                                                                                                                                         | Lalas S, et al., 2003<br>Eilert U, et al., 1981 |
|                       |                    | Saturated acids: Behenic and palmitic                                                                                                                                                       |                                                 |
|                       |                    | $\beta$ -sitosterol, stigmasterol and campesterol, $\alpha$ -, $\beta$ - and $\delta$ -tocopherols                                                                                          |                                                 |
| Leaves and Pods       |                    | 4-( $\alpha$ -L-rhamnosyloxy)-benzylisothiocyanate                                                                                                                                          |                                                 |
|                       |                    | Essential amino acids: Arginine, Cysteine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Valine, Vitamin A, B <sub>1</sub> , B <sub>2</sub> , B <sub>3</sub> , C and E | Yisehak K, et al., 2011                         |
|                       |                    | cholest-5-en-3-ol, palmitic acid, n-octacosane and oleic acid                                                                                                                               | Tesemma M, et al., 2013                         |
|                       |                    | Polyphenols, saponins, phytosteroids and withanoids, flavonoids, tannins, alkaloids and antraquinone glycosides                                                                             | Mengistu M, 2007                                |
|                       |                    | Essential amino acids for leucine, valine, phenylalanine, isoleucine and threonine                                                                                                          | Melesse A, et al., 2009                         |

|                     |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                      |
|---------------------|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <i>M. Peregrina</i> | Seeds                | 2-propyl, 2-butyl and 2-methylpropyl isothiocyanate in addition to 5,5-dimethyl-oxazolidine-2-thione, 4-(4'-O-Acetyl- $\alpha$ (-L-rhamnosyloxy)benzyl isothiocyanate,                                                                                                                                                                                                                                                                                                                                                                           | Kær A, et al., 1979                                                                  |
|                     | Seed Oil             | Oleic and gadoleic acids, saturated acids were palmitic acid and stearic acid, sterolic. Fraction of the oil: $\beta$ -sitosterol and campsterol, stigmasterol and brassicasterol and Alpha-, $\gamma$ - and d-tocopherols, Delta(7)-campestanol, clerosterol, Delta(5,24)-stigmastadienol, Delta(7)-stigmastanol and Delta(7)-avenasterol                                                                                                                                                                                                       | Tsaknis J, 1998                                                                      |
|                     | Aerial Parts         | $\beta$ -sitosterol, $\beta$ -amyrin, campsterol, stigmasterol, Quercetin, Quercetin-3-O-rutinoside (rutin), chrysoeriol-7                                                                                                                                                                                                                                                                                                                                                                                                                       | Elbatran SA, et al., 2005                                                            |
|                     |                      | O-rhamnoside and 6,8,3,5-tetramethoxy apigenin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                      |
|                     | Aerial parts         | $\beta$ -amyrin, $\alpha$ -amyrin, $\beta$ -sitosterol, $\beta$ -sitosterol-3-O-glucoside, apigenin, rhamnetin, neochlorogenic acid, rhamnetin-3-O-rutinoside, and 6-methoxy-acacetin-8-C- $\beta$ -glucoside, Quercetin, chryseriol-7-O-rhamnoside and quercetin-3-O-rutinoside                                                                                                                                                                                                                                                                 | El-Alfy TS, et al., 2011                                                             |
|                     | Aerial parts         | Lupeol acetate, $\alpha$ -amyrin, $\beta$ -amyrin, sitosterol, sitosterol-3-O-D-glucoside and apigenin                                                                                                                                                                                                                                                                                                                                                                                                                                           | Tahany MA, et al., 2010                                                              |
|                     | Seeds, leaf, stem    | Aspartic, Serine, Glutame, Proline, Glycine, Cystine, Tryosine, Phenyalanine. Essential amino acids: Threonine, methionine, lysine. leucine, isoleucine, valine, phenylalanine, histidine and arginine. Seed-Fatty Acid: Lauric, myristic, palmitic, stearic, oleic and arachidic acid                                                                                                                                                                                                                                                           | Osman HE and Abohassan AA, 2012; Al-Dabbas MM, et al., 2010; Somali MA, et al., 1984 |
|                     | Seed oil             | Campsteol, clerosterol and $\beta$ sitosterol compounds.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Al-Dabbas MM, et al., 2010; Abd El Baky HH and El-Baroty GS, 2013                    |
|                     |                      | Fatty acids: Oleic acid, linoleic acid, Tocopherols                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                      |
|                     | Seed kernel and leaf | Isobutyl isothiocyanate, isopropyl isothiocyanate, sec-butyl isothiocyanate, n-butyl isothiocyanate and benzyl isothiocyanate.                                                                                                                                                                                                                                                                                                                                                                                                                   | Afsharypuor S, et al., 2010                                                          |
|                     |                      | Volatile isothiocyanates: Isobutyl isothiocyanate, isopropyl isothiocyanate, n-butyl isothiocyanate and sec-butyl isothiocyanate                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                      |
| Leaf                |                      | Flavonoid glycoside: Rutin                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Dehshahri SH, et al., 2012                                                           |
| Stem                |                      | Stem Contain Isothiocyanates: Isopropyl isothiocyanate, sec-butyl isothiocyanate and isobutyl isothiocyanate                                                                                                                                                                                                                                                                                                                                                                                                                                     | Dehshahri S, et al., 2012                                                            |
|                     |                      | Seed Coat: Isopropyl isothiocyanate, Isobutyl isothiocyanate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                      |
| Leaves              |                      | Cyclopentanol, 1 methyl, 2-Heptanone-3-methyl, Hydroperoxide, 1-ethylbutyl, Hydroperoxide, 1-methylpentyl, Ethanone, 1-cyclohexyl, Heptadecanoic acid, methyl ester, Nonadecane, Eicosane, Heneicosane, 1-Docosene, Tricosane, Tetracosane, Pentacosane, Hexacosane, Heptacosane, Octacosane, Nonacosane, Triacontane, Acetic acid, butyl ester, Oxirane, 2,2 dimethyl 3-Propyl, Hexadecanoic acid, ethyl ester, 9-Octadecenoic acid ethyl ester, Ethylbenzene, p-Xylene, o-Xylene, Phenyl acetaldehyde, C-10-hydrocarbon, 1-Hexadecanol, Phytol | Elbatran SA, et al., 2005; Al-Owaisi M, et al., 2014                                 |
|                     |                      | O-Methyl, O-ethyl, and O-butyl, 4-(( $\alpha$ -L-rhamnosyloxy) benzyl) thiocarbamate (E), 4-( $\alpha$ -L-rhamnosyloxy) benzyl isothiocyanate                                                                                                                                                                                                                                                                                                                                                                                                    | Ayyari M, et al., 2014                                                               |

|                        |                           |                                                                                                                                                                                                                                                                                                                                                                                                        |                                                           |
|------------------------|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| <i>M. con-canensis</i> | Seed oil                  | Oleic acid, Palmitic, Stearic, Behenic, Arachidic acids, Ascorbic acid and α, γ- and δ-tocopherols                                                                                                                                                                                                                                                                                                     | Manzoor M, et al., 2007; Verma SC, et al., 1976           |
|                        | Flowers                   | Alkaloids, Flavonoids, Carbohydrates and Phytosterols                                                                                                                                                                                                                                                                                                                                                  | Jayabharathi M and Chitra M, 2011                         |
|                        | Leaves                    | Hydro alcoholic and ethyl acetate extracts indicate the presence of Alkaloids, saponins, glycosides, steroids and terpenoids                                                                                                                                                                                                                                                                           | Ravichandran V, et al., 2009                              |
|                        | Seed oil                  | Pentadeconic, 11-octadecenoic, eicosanoic, hexadecanoic and docosanoic acids                                                                                                                                                                                                                                                                                                                           | Megha G, et al., 2011                                     |
|                        | Leaves, Flowers and Seeds | Alkaloids, flavonoids, phenol and carbohydrate                                                                                                                                                                                                                                                                                                                                                         | Santhi K and Sengottuvel R, 2016                          |
|                        | Bark                      | Alkaloids, Carbohydrates, Terpenoids, Tannins, Reducing sugar and amino acid                                                                                                                                                                                                                                                                                                                           | Balamurugan V and Balakrishnan V, 2013                    |
|                        | Leaves                    | Alkaloids, Flavonoids, Carbohydrates, Terpenoids, Tannins, Reducing sugar and amino acid                                                                                                                                                                                                                                                                                                               | Bhamadevi R, 2015; Balamurugan V and Balakrishnan V, 2013 |
|                        | Leaves                    | 1,2-15,16-Diepoxyhexadecane, Butanoic Acid, 3-Cyano-3-Hydroxy-, Ethyl Ester, N-Hexadecanoic Acid, Butanoic Acid, 3-Cyano-3-Hydroxy-, Ethyl Ester, Phytol, Tetra-tetracontane, Tetratetracontane, 2-(3-(4-Tert-Butyl-Phenoxy)-2-Hydroxy-Propylsulfanyl)-4,6-Dimethyl-NI, Acetamide, N-(6-Acetylaminobenzothiazol-2-YL)-2-(Adamantan-1-YL), Nonadecane, 2-Methyl, 3,7,11,15-Tetramethyl-2-Hexadecen-1-OL | Chandasekar S and Malathi R, 2016                         |
| Bark                   |                           | Squalene                                                                                                                                                                                                                                                                                                                                                                                               | Balamurugan V, et al., 2015; Ugarte-Barco F, et al., 2018 |
|                        |                           | 1-Nonene, 4,6,8-trimethyl                                                                                                                                                                                                                                                                                                                                                                              |                                                           |
|                        |                           | Trimethyl (4-tert-butylphenoxy silane)                                                                                                                                                                                                                                                                                                                                                                 |                                                           |
|                        |                           | 1-Hexanol, 2-ethyl-2-propyl                                                                                                                                                                                                                                                                                                                                                                            |                                                           |
|                        |                           | 2,4,6-cycloheptatrien-1-one,3,5-bistrimethylsilyl                                                                                                                                                                                                                                                                                                                                                      |                                                           |
|                        |                           | 1,2-Benzenedicarboxylic acid, mono (2-ethylhexyl) ester                                                                                                                                                                                                                                                                                                                                                |                                                           |
|                        |                           | 2-Bromonane                                                                                                                                                                                                                                                                                                                                                                                            |                                                           |
|                        |                           | Hexanedioic acid, bis (2-ethylhexyl)                                                                                                                                                                                                                                                                                                                                                                   |                                                           |
|                        |                           | Heptane, 2,2,3,3,5,6,6-Heptamethyl                                                                                                                                                                                                                                                                                                                                                                     |                                                           |
|                        |                           | Dibutyl phthalate                                                                                                                                                                                                                                                                                                                                                                                      |                                                           |
|                        |                           | Heptanoic acid, 2-ethyl                                                                                                                                                                                                                                                                                                                                                                                |                                                           |
|                        |                           | 4-Dodecanol                                                                                                                                                                                                                                                                                                                                                                                            |                                                           |
|                        |                           | 1,14-Tetradecanediol                                                                                                                                                                                                                                                                                                                                                                                   |                                                           |
|                        |                           | 1-Hepten-4-ol                                                                                                                                                                                                                                                                                                                                                                                          |                                                           |
|                        |                           | 4-Nonene, 3-methyl                                                                                                                                                                                                                                                                                                                                                                                     |                                                           |
|                        |                           | Isooctanol                                                                                                                                                                                                                                                                                                                                                                                             |                                                           |
| Leaf                   |                           | Pantolactone                                                                                                                                                                                                                                                                                                                                                                                           | Balamurugan V, et al., 2015; Ugarte-Barco F, et al., 2018 |
|                        |                           | DL-3-4 Dimethyl-3,4-hexanediol                                                                                                                                                                                                                                                                                                                                                                         |                                                           |
|                        |                           | 3,4 dimethyl 5 hexen 3-ol                                                                                                                                                                                                                                                                                                                                                                              |                                                           |
|                        |                           | 1,5-Hepatadiene, 3,3, Dimethyl-(E)                                                                                                                                                                                                                                                                                                                                                                     |                                                           |
|                        |                           | Pentane, 1, 3-epoxy-4 methyl                                                                                                                                                                                                                                                                                                                                                                           |                                                           |
|                        |                           | Butanic acid, 2, hydroxyl-2-methyl, methyl ester                                                                                                                                                                                                                                                                                                                                                       |                                                           |
|                        |                           | 3-Dodecen-1-ol                                                                                                                                                                                                                                                                                                                                                                                         |                                                           |
|                        |                           | 1,3-Dioxolane, 2                                                                                                                                                                                                                                                                                                                                                                                       |                                                           |
|                        |                           | 2,2'-Bioxirane, Allylipo nitrite                                                                                                                                                                                                                                                                                                                                                                       |                                                           |
|                        |                           | 3-Butyn-2-ol                                                                                                                                                                                                                                                                                                                                                                                           |                                                           |
|                        |                           | 3 buten-2-ol                                                                                                                                                                                                                                                                                                                                                                                           |                                                           |
|                        |                           | 3,4 dimethyl 5 hexen 3-ol                                                                                                                                                                                                                                                                                                                                                                              |                                                           |
|                        |                           | 2-propanoic acid, 2 propanyl ester                                                                                                                                                                                                                                                                                                                                                                     |                                                           |
|                        |                           | 3-Pentanol,2,4 Dimethyl                                                                                                                                                                                                                                                                                                                                                                                |                                                           |
|                        |                           | Flavanoid: Kaempferol, Quercetin and Myriethin                                                                                                                                                                                                                                                                                                                                                         |                                                           |
|                        |                           |                                                                                                                                                                                                                                                                                                                                                                                                        |                                                           |
| <i>M. Ovalifolia</i>   | Leaves                    |                                                                                                                                                                                                                                                                                                                                                                                                        | Balamurugan V, et al., 2015; Ugarte-Barco F, et al., 2018 |

Moreover *Moringa* species is edible, very little nutritional bioavailability and information available. *M. oleifera* contain high calcium and protein levels, anatomical work shows that all herbal parts are packed with calcium oxalate crystals. For the determination of protein, most analytical methods examine total N rather than bioavailable protein. This is potentially important that the calcium in oxalates in *Moringa Oleifera* plant available as a dietary calcium source not as a *Moringa* protein and mineral consideration. The ingestion of high levels of soluble oxalates can contribute to kidney stones but the authors found only non-soluble oxalates in plant, which are excreted and thus do not contribute to calculi. Thus, determining the relationship between nutrition value of *Moringa* species and palatability is commonly necessary. The wide range of *Moringa* and its species, across the dry tropics of Africa, Asia and Madagascar, makes broadly surveying the genetic diversity of each species a challenge because many of the ranges of the species are inaccessibility.

There is no reported literature on the phytochemistry *Moringa Arborea*, *M. riva*, *M. Borziana*, *M. Ruspoliana*, *M. Pygmaea*, *M. Hildebrandtii*, *M. Longituba* and *M. drouhardii*.

### Pharmacology

*Moringaceae* products are frequently suggested by traditional ayurvedic practitioner and used by patients in many countries to cure or prevent disease as well as also sold as over-the-counter natural medicines for nutritional supplements and derived from raw plant tissue or plant extracts. There are many digital platforms where herbal supplements sell for the wellness, nutritional supplement and immunomodulatory effect. One of the most studied species in the *moringaceae* family is *Moringa Oleifera* from a nutritional and biological perspective, and both evaluations are commonly based on the traditional uses of plant. Other remaining species of *Moringaceae* family also studied and evaluations are normally based on

the traditional therapeutic uses. Since the chemical constituent's variability of the plants, the important identified compounds are cited when available. Table 3 lists the biological activities of *Moringacea* species.

### Toxicology

Natural or dietary nutritional supplement or herbal products are likely to be effective and safe for treating or preventing disease with appropriate knowledge. Due to the complex chemical nature of herbal nutritional supplements which is makes it difficult to evaluate their potency, efficacy and safety. Herbal nutritional or dietary products often show great variability in quality because of some issues including authentication, substitution and adulteration and environment as well as soil factors during growth, harvest, and postharvest processing (Guo L, et al., 2010).

The reported adverse effects of herbal supplement and formulation have higher related to public health risks including the quantity, concentration, composition, and specific contaminants/ adulteration of dietary supplements. Herbal dietary nutritional supplements and other ayurvedic products have been documented as the common causes of drug-induced liver injury (Ruan J, et al., 2015). A current report indicates that dietary/herbal nutritional supplements are produced 19% of drug-induced acute liver failure cases, (Goldberg DS, et al., 2015) since consumers/patients often buy these products online without the supervision and concern with the health care provider and are not aware of synthetic drug and herbal formulation interactions and appropriate warnings.

From the *Moringaceae* family various plant part leaves, bark, seeds, roots, flowers and sap are commonly used in traditional medicine, and the leaf and immature seed pods are used as food supplement and products as a human nutrition. In Table 4, Toxicology Studies of *Moringaceae* Family Plant research article data was shown.

Table 3: Biological activities of *Moringaceae*

| Plant name         | Part(s) used                | Extract                                                    | Biological activity                                            | Reference                                              |
|--------------------|-----------------------------|------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------------|
| <i>M. oleifera</i> | Leaves                      | Methanol extract ( $ID_{50}$ value=0.32 $\mu\text{g/ml}$ ) | Antimyelomic activity                                          | Parvathy MV and Umamaheshwari A, 2007                  |
|                    | Seed                        | Hydro alcoholic extract and Aqueous extract                | Anti-cancer activity                                           | Masood MK, 2010                                        |
|                    | Leaves                      | Aqueous extract                                            | Antioxidant properties, Hypolipidaemic and Antiatherosclerotic | Chumark P, et al., 2008                                |
|                    | Leaves                      | Aqueous extract                                            | Antioxidant activity                                           | Verma AR, et al., 2009; Sreelatha S and Padma PR, 2009 |
|                    | Leaves, Stem and Root barks | Methanol extract                                           | Antioxidant activity                                           | Atawodi SE, et al., 2010                               |
|                    | Leaves                      | Ethanolic extract, Methanolic extract                      | Immunomodulatory effect                                        | Gupta A, et al., 2010; Sudha P, et al., 2010           |
|                    | Leaves                      | Aqueous extract                                            | Anti-nociceptive and Anti-inflammatory properties              | Sulaiman MR, et al., 2008                              |
|                    | leaves                      | Hydroalcoholic extract                                     | Anti-inflammatory properties                                   | Mahajan SG and Mehta AA, 2009                          |
|                    | Fruits                      | Ethyl acetate extract                                      | Anti-inflammatory properties                                   | Cheenpracha S, et al., 2010                            |
|                    | Seed                        | Ethanolic extract                                          | Anti-inflammatory properties                                   | Mahajan SG and Mehta AA, 2010                          |
|                    | Seed                        | Ethanol extract                                            | Antitumor                                                      | Guevara AP, et al., 1999                               |
|                    | Pod                         |                                                            | Anti-inflammatory properties                                   | Muangnoi C, et al., 2012                               |
|                    | Leaves                      | Aqueous extract                                            | Anti-hyperglycemic activity                                    | Jaiswal D, et al., 2009                                |
|                    | Leaves                      | leaf powder                                                | Anti-hyperglycemic activity                                    | Ndong M, et al., 2007                                  |
|                    | Leaves                      |                                                            | Anti-hyperglycemic activity                                    | William F, et al., 1993; Ghiridhari VV, et al., 2011   |

|                   |                                                      |                                                                                              |                                                                    |
|-------------------|------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Leaves            | leaf powder                                          | Hypoglycaemic effect in Type 2 Diabetes Mellitus, Anti Hyperlipidemic effect (Human Studies) | Kumari DJ, 2010                                                    |
| Leaves            |                                                      | Hypocholesterolemic agent                                                                    | Ghasi S, <i>et al.</i> , 2000                                      |
| Leaves            | Methanolic extract                                   | Hypolipidemic effect                                                                         | Jain PG, <i>et al.</i> , 2010                                      |
| Leaves            | Aqueous extract                                      | Anti-hyperglycaemic and Anti hyperlipidemic effect                                           | Divi SM, <i>et al.</i> , 2012                                      |
| Leaves            | Leaf tablet                                          | Antioxidant properties, Hypolipidaemic effect (Human Studies)                                | Nambiar VS, <i>et al.</i> , 2010                                   |
| Seed              |                                                      | Anti-diabetic effect                                                                         | Al-Malki AL and El Rabey HA, 2015                                  |
| leaves            | Hydro alcoholic Extract                              | Cerebroprotective effect                                                                     | Kirisattayakul W, <i>et al.</i> , 2013                             |
| Seeds and Leaves  | Ethanol extracts                                     | Anti-fungal activity                                                                         | Chuang PH, <i>et al.</i> , 2007                                    |
| Leaves            | Hydro alcoholic Extract                              | Treat dementia                                                                               | Sutalangka C, <i>et al.</i> , 2013                                 |
| Leaves            | leaf powder                                          | Nephro protective effect                                                                     | Adeyemi OS and Elebiyo TC, 2014                                    |
| leaves            | Ethanol extract                                      | Neurobehavioral and anticonvulsant effect                                                    | Bakre AG, <i>et al.</i> , 2013                                     |
| leaves            | aqueous extract                                      | Anxiolytic and antiepileptic effects                                                         | Ingale SP and Gandhi FP, 2016                                      |
| Root-bark extract | Ethanol extracts                                     | Antiulcer, antisecretory, and cytoprotective activity                                        | Choudhary MK, <i>et al.</i> , 2013                                 |
| Flowers           | Hydro alcoholic Extract                              | Anti-arthritis activity                                                                      | Mahajan SG and Mehta AA, 2009                                      |
| Seeds             | Aqueous and ethanolic extracts                       | Antibacterial effect Gram positive and Gram negative bacteria                                | Viera GH, <i>et al.</i> , 2010                                     |
| Plant             | Aqueous extract                                      | Cytotoxic effects on Hela cells                                                              | Nair S and Varalakshmi KN, 2011                                    |
| Leaves            | Aqueous And Chloroform extract                       | Antibacterial effect                                                                         | Abalaka ME, <i>et al.</i> , 2012                                   |
| Leaves            | Methanolic extract                                   | Antiulcer activity                                                                           | Pal SK, <i>et al.</i> , 1995                                       |
| Drumsticks        | Hydro-alcoholic extract                              | Chemo modulatory effect                                                                      | Bharali R, <i>et al.</i> , 2003                                    |
| Fruits            |                                                      | Hypolipidaemic effect                                                                        | Mehta K, <i>et al.</i> , 2003                                      |
| Root Barks        | Chloroform extract                                   | Antimicrobial activity                                                                       | Nikkon F, <i>et al.</i> , 2003                                     |
| Leaf Stalk        | Aqueous extract                                      | Antimicrobial activity                                                                       | Thilza IB, <i>et al.</i> , 2010                                    |
| Pod               | Hydro-ethanolic extraction                           | Antinephrotoxic effect                                                                       | Paliwal R, <i>et al.</i> , 2011                                    |
| Seed              | Ethanolic extraction                                 | Anti-pyretic effect                                                                          | Sutar NG, <i>et al.</i> , 2009                                     |
| Seed              | n-Butanol extract                                    | Anti-asthmatic effect                                                                        | Mahajan SG, <i>et al.</i> , 2009                                   |
| Seed kernels      |                                                      | Anti-asthmatic effect                                                                        | Agrawal B and Mehta A, 2008                                        |
| Seeds             | Ethanolic extract                                    | Anti-arthritis activity                                                                      | Mahajan SG, <i>et al.</i> , 2007                                   |
| Leaves            | Aqueous extract                                      | Wound healing property                                                                       | Rathi BS, <i>et al.</i> , 2006                                     |
| Seeds             | Ethanolic and ethyl acetate extracts                 | Antipyretic activity                                                                         | Hukkeri VI, <i>et al.</i> , 2006                                   |
| Leaves            | Ethyl acetate extract                                | Wound healing activity                                                                       |                                                                    |
| Leaves            | Aqueous extract                                      | Anti-Hyperthyroidism effect                                                                  | Tahiliani P and Kar A, 2000                                        |
| Leaves and Seed   | fresh leaf juice and aqueous extracts from the seeds | Antimicrobial activity                                                                       | Caceres A, <i>et al.</i> , 1991                                    |
| Root              | Chloroform extract                                   | Antimicrobial activity and Anti-fungal activity                                              | Nikkon F, <i>et al.</i> , 2003                                     |
| Leaves            |                                                      | Anti-fungal activity                                                                         | Ayanbimpe GM, <i>et al.</i> , 2009                                 |
| Seed              |                                                      | Anti-cyanobacterial activity                                                                 | Lürling M and Beekman W, 2010                                      |
| Seed              |                                                      | Hepato-protective effect                                                                     | Hamza AA, 2007                                                     |
| Leaves            | Ethanolic extract                                    | Hepato-protective effect                                                                     | Pari L and Kumar NA, 2002                                          |
| Leaves            |                                                      | Hepato-protective effect                                                                     | Selvakumar D and Natarajan P, 2008                                 |
| Plant, Leaves     |                                                      | Hepato-protective effect                                                                     | Fakurazi S, <i>et al.</i> , 2008; Fakurazi S, <i>et al.</i> , 2012 |
| Seed              |                                                      | Ameliorative effects, antioxidant properties, anti-inflammatory effect                       | Hamza AA, 2010                                                     |

|                                |                                                           |                                                                              |                              |
|--------------------------------|-----------------------------------------------------------|------------------------------------------------------------------------------|------------------------------|
| Leaves                         | Methanolic extract                                        | Radio protective effect                                                      | Rao AV, et al., 2001         |
| Flower bud                     | -                                                         | Anti-ulcerogenic activity                                                    | Akhtar AH and Ahmad KU, 1985 |
| Flowers,                       | Water infusions                                           | antispasmodic,                                                               | Cáceres A, et al., 1992      |
| Leaves, root, seeds,           |                                                           | Anti-inflammatory and                                                        |                              |
| stalks                         |                                                           | Diuretic activity                                                            |                              |
| Seed                           | Ethanol                                                   | Antitumor promoter                                                           | Guevara AP, et al., 1999     |
| Seed                           | Seed powder                                               | Inhibit arsenic-induced toxicity                                             | Gupta R, et al., 2005        |
| Leaves                         | Hydro alcoholic extract                                   | Cardio protective activity (Isoproterenol induced myocardial damage in rats) | Nandave M, et al., 2009      |
| Pods                           | Hydroethanolic                                            | Reno protective effects                                                      | Sharma V, et al., 2012       |
| Leaves and Root                | Methanolic                                                | Antiarthritis activity                                                       | Manaheji H, et al., 2011     |
| Leaves                         | Ethanol                                                   | Anti-oxidative stress                                                        | Sinha M, et al., 2011        |
| Seed                           | Chitin-binding protein from <i>Moringa oleifera</i> seeds | Antinociceptive and anti-inflammatory effects                                | Pereira ML, et al., 2011     |
| Leaves and Root                | Aqueous                                                   | Wound healing (Protease activity)                                            | Satish A, et al., 2012       |
| Leaf and Fruit                 | Ethanolic extracts                                        | Antistress, Antioxidant                                                      | Luqman S, et al., 2012       |
| Leaves                         | Ethanol                                                   | Antioxidant activity                                                         | Moyo B, et al., 2012         |
| Pod                            | Methanol                                                  | Anti-diabetic and antioxidant activity                                       | Gupta R, et al., 2012        |
| -                              | -                                                         | Retinoprotective effects (Preventing diabetes induced retinal dysfunction)   | Gupta SK, et al., 2013       |
| Leaves formulated in to Tablet | Tablet                                                    | Anti-diabetic activity                                                       | Momoh MA, et al., 2013       |
|                                |                                                           | Nephrotoxicity activity (Gentamicin-induced nephrotoxicity)                  | Ouédraogo M, et al., 2013    |

Table 4: Toxicology studies of Moringaceae family plant

| Plant name         | Part(s) used | Extract          | Toxicology studies detail                                                                                                               | Result                                                                                                                                                                                                                                                                                                  | Ref.                      |
|--------------------|--------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| <i>M. oleifera</i> | Seeds        | Aqueous extracts | Aqueous extracts of <i>Moringa oleifera</i> seeds in Nile tilapia, <i>Oreochromis niloticus</i> , fingerlings and adults.               | Toxic reaction exhibited by the fish includes erratic movement, air gulping, loss of reflex, discolouration, molting, loss of scale, and haemorrhage. Mortality increased with increase in concentration of <i>M. oleifera</i> and time of exposure in both <i>O. niloticus</i> fingerlings and adults. | Ayotunde EO, et al., 2011 |
|                    | Leaves       | Aqueous extract  | The aqueous extract from the leaves of <i>Moringa oleifera</i> was evaluated for its oral toxicity by the oral route in rats            | In the acute toxicity test, <i>M. oleifera</i> extract caused no death in animals even at 2000 mg/kg dose                                                                                                                                                                                               | Adedapo AA, et al., 2009  |
|                    | Seeds        | Methanol extract | The methanol extract was screened phytochemically for its chemical components and used for acute and subacute toxicity studies in rats. | The signs of acute toxicity were observed at a dose of 4,000 mg kg <sup>-1</sup> in the acute toxicity test, and mortality was recorded at 5,000 mg kg <sup>-1</sup> , no adverse effect was observed at concentrations lower than 3,000 mg kg <sup>-1</sup> .                                          | Ajibade TO, et al., 2013  |
|                    | Seeds        | Aqueous extract  | <i>Moringa oleifera</i> aqueous leaf extract to induce cytotoxicity in Sprague-Dawley (SD) rats.                                        | The <i>M. oleifera</i> leaf extract was shown to be genotoxic based on blood cell analysis at the 3000 mg/kg dose. A dose of 1000 mg/kg was deemed safe and did not produce genotoxicity when given to rats.                                                                                            | Asare GA, et al., 2012    |

|  |        |                      |                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                |
|--|--------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
|  | Leaves | Powder of leaves     | Toxicity evaluation of <i>Moringa oleifera</i> leaves powder in Albino (Wister stains) rats.                                                                                                                                                                                             | The result of the study revealed that some organs of the treated animals had observable microscopical lesions, while the control animals had no observable microscopic lesions in all the organs examined.                                                                                                                                                                                                                                                                                                                                                                                                                         | Ambi AA, et al., 2011          |
|  | Leaves | Powder of leaves     | Acute toxicity of <i>Moringa oleifera</i> leaf powder in Sprague Dawley rats.                                                                                                                                                                                                            | This study indicated that oral administration of <i>Moringa oleifera</i> dried leaf powder up to 2000 mg/kg showed no changes in clinical signs or gross pathology and that the LD <sub>50</sub> was greater than 2000 mg/kg.                                                                                                                                                                                                                                                                                                                                                                                                      | Moodley I, 2017                |
|  | Leaves | Powder of leaves     | Evaluation of sub chronic toxicity of <i>Moringa oleifera</i> leaf powder in Balbc Mice                                                                                                                                                                                                  | This study indicated that oral administration of <i>Moringa oleifera</i> dried leaf powder at a 1000 mg/kg daily showed no changes in clinical signs or gross pathology over a prolonged chronic exposure period of 90 day.                                                                                                                                                                                                                                                                                                                                                                                                        | Moodley I, 2018                |
|  | Leaves | Aqueous leaf extract | In an acute toxicity test, male Wistar albino mice were orally administered an aqueous extract up to 6400 mg/kg and intraperitoneally up to 2000 mg/kg. A sub-chronic toxicity test was performed by daily administration with the extract at 250, 500 and 1500 mg/kg orally for 60 days | The LD <sub>50</sub> was estimated to be 1585 mg/kg. The extract did not elicit any significant difference (P ≥ 0.05) in sperm quality, haematological and biochemical parameters in the treated rats compared to the control.                                                                                                                                                                                                                                                                                                                                                                                                     | Awodele O, et al., 2012        |
|  | Leaves | Aqueous Extract      | Toxicological assessment of aqueous extract of <i>Moringa oleifera</i> leaves in Rabbits                                                                                                                                                                                                 | The effects of the leave extracts on the haematological parameters, selected liver enzymes, insulin level and body weights of the affected rabbits were analysed. There were significant increases in CD4 cells (p<0.01), lymphocytes (p<0.05) and a decrease in neutrophils (p<0.05). There was an enhancement in the activities of acid phosphatase, alkaline phosphatase, aspartate transaminase and alanine transaminase in rabbits exposed to 2.5 mL of the extract. There was no significant difference in the histology of major organs, weights and the physical and behavioural pattern of both test and control rabbits. | Isitua CC and Ibeh IN, 2013    |
|  | Leaves | Methanol extract     | Toxicological evaluations of Methanolic Extract of <i>Moringa oleifera</i> (MEMO) leaves in liver and kidney of male Wistar rats.                                                                                                                                                        | There was a significant (p<0.05) increase in serum total protein, globulin and body weight in a dose-dependent manner. Rats that received MEMO at 200 and 400 mg/kg b.w. showed a significant (p<0.05) increase in serum ALT, AST, BUN and creatinine which pointed to hepatic and kidney damage.                                                                                                                                                                                                                                                                                                                                  | Oyagbemi AA, et al., 2013      |
|  | Seeds  | Aqueous extract      | Cytotoxicity of an aqueous extract of <i>M. oleifera</i> seeds was evaluated in mice. (Dose: 500 and 2000 mg/kg)                                                                                                                                                                         | No signs of systemic toxicity were observed, and all the animals survived. There were no changes in organ indices between treatment and control groups. Small but insignificant changes were observed in erythrocytes, platelets, haemoglobin, and haematocrit.                                                                                                                                                                                                                                                                                                                                                                    | Araújo LC, et al., 2013        |
|  | Seed   |                      | Genotoxicity assessment of an extract of <i>M. oleifera</i> seed powder and the Water-Soluble <i>Moringa oleifera</i> Lectin (WSMoL) isolated from seeds.                                                                                                                                | The seed extract was not genotoxic without metabolic activation, and did not pose a risk to human health.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Rolim LA, et al., 2011         |
|  | Leaves | aqueous extract      | Acute toxicity (5000 mg/kg) and sub-acute toxicity studies of the leaf (40 mg/kg to 1000 mg/kg) extract were conducted in rats.                                                                                                                                                          | There were no observed overt adverse reactions in the acute and sub-acute studies. Although there were observed elevations in liver enzymes ALT and ALP and lower creatinine levels in the extract treated groups, no adverse histopathological findings were found.                                                                                                                                                                                                                                                                                                                                                               | Asiedu-Gyekye IJ, et al., 2014 |

|                            |                  |                                                        |                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                |
|----------------------------|------------------|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
|                            | Leaves and seeds | water extract and ethanol extracts of leaves and seeds | Cytotoxicity of extracts from <i>Moringa stenopetala</i> leaves and seeds was assessed in HEPG2 cells, by measuring the leakage of Lactate Dehydrogenase (LDH) and cell viability. (Dose: concentration of 500 mg/mL)                         | The water extract of the leaves did not alter GSH or LDH levels or affect cell viability, suggesting that it may be non-toxic, and is consistent with its use as a vegetable. The data obtained from the studies with the ethanol extract of the leaves and seeds from <i>Moringa stenopetala</i> show that they contain toxic substances that are extractable with organic solvents or are formed during the process of extraction with these solvents.                                                   | Mekonnen N, et al., 2005       |
|                            | Roots            | Methanol extract                                       | Methanolic extract of <i>Moringa oleifera</i> Lam. root on Histo-architechture of liver and kidney in guinea pigs. (Dose: Daily intraperitoneal injections of the root extract at doses of 3.6, 4.6, and 7.0 mg/kg, and control for 3 weeks.) | Histological sections of all treated groups had ballooning degeneration of the liver, suggesting time-dependent hepatotoxicity rather than a dose-dependent response. This study involved a methanol extract of roots, which was given intraperitoneally and not orally.                                                                                                                                                                                                                                   | Paul CW and Didia BC, 2012     |
| <i>Moringa stenopetala</i> | Leaves           | Butanol fraction                                       | Acute toxic effect of butanol fraction of the leaves in experimental rats.                                                                                                                                                                    | Did not produce adverse effects in treated rats after acute treatment.                                                                                                                                                                                                                                                                                                                                                                                                                                     | Musa A, et al., 2015           |
|                            |                  |                                                        | Dosage Given: 500 mg/kg-5000 mg/kg respectively of the fraction                                                                                                                                                                               | No toxic signs on behavior, gross pathology, and body weight, as compared with the controls.                                                                                                                                                                                                                                                                                                                                                                                                               |                                |
|                            | Leaves           | Butanol fraction                                       | Sub chronic toxicity studies of butanol fraction of leaves of <i>Moringa stenopetala</i> in experimental rats.                                                                                                                                | In the Sub chronic toxicity study, results showed that the fraction did not produce adverse effects and toxicity. The fraction did not significantly, induce severe toxic effects on the gross and histopathology of the liver and kidneys of treated rats, except infiltration of inflammatory cells around the portal area of the liver and Bowman's capsule of the kidney sections.                                                                                                                     | Musa AH, et al., 2015          |
|                            |                  |                                                        | Dosage given: 500 mg/kg-1000 mg/kg respectively of the fraction                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                |
|                            | Leaves           | Aqueous extract                                        | The effects of <i>Moringa stenopetala</i> on blood parameters and histopathology of liver and kidney in mice.                                                                                                                                 | The aqueous leaf extract of <i>M. stenopetala</i> is shown to increase body weight and reduce serum glucose and cholesterol level in mice. Neither a significant change in the weight nor in histopathology of liver and kidney were observed in the animals.                                                                                                                                                                                                                                              | Ghebreselassie D, et al., 2011 |
|                            |                  |                                                        | Dosage given: 900 mg/kg                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                |
|                            | Leaves           | Ethanol extracts of leaves                             | The acute toxicity study of the extracts and fractions of <i>Moringa stenopetala</i> leaves in liver and kidney of female Wistar rats                                                                                                         | The acute toxicity study found no signs of toxicity; hence LD <sub>50</sub> was greater than 5000 mg/kg. The biochemical test revealed that extracts produced a rise in liver in a dose dependent manner but no effect on kidney function indicators compared with normal control.                                                                                                                                                                                                                         | Geleta B, et al., 2016         |
| <i>Moringa peregrina</i>   | Seeds            | Extraction of fixed oil                                | Acute toxicity study on <i>Moringa peregrina</i> fixed oil in Albino Rats                                                                                                                                                                     | The results show that oral administration of <i>Moringa peregrina</i> seeds oil in doses of 3000-18000 mg/kg. Resulted in mortalities. The dose of <i>Moringa peregrina</i> seeds oil that killed half of the rats (LD <sub>50</sub> ) was 11450 mg/kg b.w. The results of liver and renal histopathology confirmed that the death of rats. It can be concluded that the <i>Moringa peregrina</i> fixed oil is safe and had low toxicity effect when given in concentrated doses for short period of time. | Kahilo K, et al., 2015         |

|                                  |        |                 |                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                      |
|----------------------------------|--------|-----------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
|                                  | Seeds  | Dry seed        | Toxic effect of <i>Moringa peregrina</i> seeds on histological and biochemical analyses of adult male Albino rats | Daily doses of 0, 500, 1000 and 2000 mg/kg body weight of dry seed of <i>M. peregrina</i> were administered orally to 4 groups of rats for 14 days. No histopathological changes were detected in the body tested organs. In consequences, intake of different doses of <i>M. peregrina</i> , even high one, exhibit no organ toxicity and are safe for human use.                                                                                                                                                                                                                                                                      | El-Hak HN, et al., 2018              |
| <i>Moringa concanensis</i> Nimmo | Leaves | Ethanol extract | Toxicity evaluation of the ethanol extract of <i>Moringa concanensis</i> Nimmo leaves in Wistar rats              | During the acute toxicity study, no sign of mortality was observed when rats were administered dose of 100, 250, 500, 1000 and 2000 mg/kg ( $p<0.05$ ). Similarly, there were no significant changes in body weight, food consumption, haematology, gross necropsy and histopathological examinations. The results of the current study explored that the treatment with this plant extract for 14 days did not produce significant toxicity. Therefore, our study suggests that the use of appropriate level of <i>M. concanensis</i> Nimmo extract as traditional medicine should have a wide range of safety for its therapeutic use | Balakrishnan BK, Krishnasamy K, 2018 |

## DISCUSSION AND CONCLUSION

There was a significant variation in ethnopharmacology, phytoconstituent, pharmacology as well as micronutrients and macro elements in different species of moringaceae for some elements but also some did not show significant differences. This might be attributed to the variable uptake of minerals by the plants and variable agro ecologies of the different regions. *M. oleifera*, *M. Peregrine*, *M. stenopetala*, and *M. concanensis* is the maximum well-known of the species and its given recognition as a food and medicinal plant for several disease. However, more studies needs to be done on other species of moringaceae family for its potential as food and medicinal plant. *Moringa* as well as other Moringaceae family plant should be encouraged for more consumption to human for better nutrition and medicinal functions.

From this review we conclude that from the Moringaceae family very few species identified to be consumed as leaf vegetables by native people are *M. oleifera*, *M. stenopetala* and *M. concanensis*. Many of unknowns' species remain regarding their nutritional qualities across other Moringaceae family species. Although in this literature we have review the possible dietary nutritional value of remaining species, nearly nothing is reported regarding composition such as the amino acid complement of their proteins, vitamin and the presence of anti-nutritional compounds, or even their edibility. Therefore, such basic information regarding species of potential interest should determining such as *M. longituba* or *M. ruspoliana*. Due to lacking of knowledge about Moringaceae family species, many people are used locally in their native ranges as a medicine, not as a nutritional food supplement.

## REFERENCES

1. Berushka P, Himansu B. An overview of the medicinal importance of Moringaceae. J Med Plants Res. 2012; 6(48): 5831-5839.
2. Mabberley DJ. The Plant Book. Cambridge University Press. 1987.
3. Olson ME. Combining data from DNA sequences and morphology for a phylogeny of Moringaceae (Brassicales). Syst Bot. 2002; 27(1): 55-73.
4. Olson ME. The home page of the plant family Moringaceae. Missouri Botanical Garden. 1999.
5. Taiga A, Friday E. Variations in phytochemical properties of selected fungicidal aqueous extracts of some plant leaves in Kogi state, Nigeria. Am-Eurasian J Sustain Agric. 2009; 3(3): 407-409.
6. Arias TD. Glossary Drugs: Development, Evaluation and Use. The Pan American Health Organization. 1999.
7. Owolabi MA, Coker HA, Jaja SI. Flavonoid metabolites in urine after oral administration of aqueous extract of *Persea americana* to rats. J Nat Med. 2007; 61(2): 200-204.
8. Sen S, Chakraborty R, de B. Challenges and opportunities in the advancement of herbal medicine: India's position and role in a global context. J Herb Med. 2011; 1(3-4): 67-75.
9. Brahmachari UN. The role of science in the recent progress of medicine. Curr Sci. 2001; 81(1): 15-16.
10. Rates SM. Plants as source of drugs. Toxicon. 2001; 39(5): 603-613.
11. Afolabi CA, Ibukun EO, Emmanuel A, Obuotor EM, Farombi EO. Phytochemical constituent and antioxidant activity of extract from the leaves of *Ocimum gratissimum*. Sci Res Essays. 2007; 2(5): 163-166.
12. Edeoga HO, Okwu DE, Mbaebie BO. Phytochemical constituents of some Nigerian medicinal plants. Afr J Biotechnol. 2005; 4(7): 685-688.
13. Prajapati D, Purohit S, Sharma A, Kumar T. A Handbook of medicinal plants. Agrobios. 2004.
14. Purohit S, Vyas S. Medicinal plant cultivation: A scientific approach. Agrobios. 2004; 624.
15. Jayabharathi M, Chitra M. Evaluation of anti-inflammatory, analgesic and antipyretic activity of *Moringa concanensis* Nimmo. J Chem Pharm Res. 2011; 3(2): 802-806.
16. Fahey JW. *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic, and prophylactic properties. Trees for Life Journal. 2005; 1(5): 1-5.
17. Morton JF. The horseradish tree, *Moringa pterygosperma* (Moringaceae)-a boon to arid lands?. Econ Bot. 1991; 45(3): 318-333.
18. Cáceres A, Saravia A, Rizzo S, Zabala L, de Leon E, Nave F. Pharmacologic properties of *Moringa oleifera*. 2: Screening for antispasmodic, antiinflammatory and diuretic activity. J Ethnopharmacol. 1992; 36(3): 233-237.
19. Pal SK, Mukherjee PK, Saha BP. Studies on the antiulcer activity of *Moringa oleifera* leaf extract on gastric ulcer models in rats. Phytother Res. 1995; 9(6): 463-465.

20. Eilert U, Wolters B, Nahrstedt A. The antibiotic principle of seeds of *Moringa oleifera* and *Moringa stenopetala*. *Planta Med.* 1981; 42(05): 55-61.
21. Guevara AP, Vargas C, Sakurai H, Fujiwara Y, Hashimoto K, Maoka T, et al. An antitumor promoter from *Moringa oleifera* Lam. *Mutat Res Genet Environ Mutagen.* 1999; 440(2): 181-188.
22. Buraimoh AA, Bako IG, Ibrahim FB. Hepatoprotective effect of ethanolic leave extract of *Moringa oleifera* on the histology of paracetamol induced liver damage in Wistar rats. *Int J Anim Vet Adv.* 2011; 3(1): 10-13.
23. El-Alfy TS, Ezzat SM, Hegazy AK, Amer AM, Kamel GM. Isolation of biologically active constituents from *Moringa peregrina* (Forssk.) Fiori. (family: Moringaceae) growing in Egypt. *Pharmacogn Mag.* 2011; 7(26): 109.
24. Anbazhakan S, Dhandapani R, Anandhakumar P, Balu S. Traditional medicinal knowledge on *Moringa concanensis* Nimmo of perambalur District, Tamilnadu. *Anc Sci Life.* 2007; 26(4): 42.
25. Arora DS, Onsare JG, Kaur H. Bioprospecting of *Moringa* (Moringaceae): microbiological perspective. *J Pharmacogn Phytochem.* 2013; 1(6).
26. Aaron K. *Moringa*: One of the world's most abundant sources of natural vitamins and minerals. *Reset.* 2022.
27. Mahmood KT, Mugal T, Haq IU. *Moringa oleifera*: A natural gift-a review. *J Pharm Sci Res.* 2010; 2(11): 775.
28. Chumark P, Khunawat P, Sanvarinda Y, Phornchirasilp S, Morales NP, Phivthong-Ngam L, et al. The *in vitro* and *ex vivo* antioxidant properties, hypolipidaemic and antiatherosclerotic activities of water extract of *Moringa oleifera* Lam. leaves. *J Ethnopharmacol.* 2008; 116(3): 439-446.
29. Kasolo JN, Bimenya GS, Ojok L, Ochieng J, Ogwal-Okeng JW. Phytochemicals and uses of *Moringa oleifera* leaves in Ugandan rural communities. *J Med Plant Res.* 2010; 4: 753-757.
30. William F, Lakshminarayanan S, Chegu H. Effect of some Indian vegetables on the glucose and insulin response in diabetic subjects. *Int J Food Sci Nutr.* 1993; 44(3): 191-195.
31. Ghiridhari VV, Malhati D, Geetha K. Anti-diabetic properties of drumstick (*Moringa oleifera*) leaf tablets. *Int J Health Nutr.* 2011; 2(1): 1-5.
32. Nambiar VS, Guin P, Parnami S, Daniel M. Impact of antioxidants from drumstick leaves on the lipid profile of hyperlipidemics. *J Herb Med Toxicol.* 2010; 4(1): 165-172.
33. Kumari DJ. Hypoglycaemic effect of *Moringa oleifera* and *Azadirachta indica* in type 2 diabetes mellitus. *Bioscan.* 2010; 5(20): 211-214.
34. Tiloche C, Phulukdaree A, Chuturgoon AA. The antiproliferative effect of *Moringa oleifera* crude aqueous leaf extract on cancerous human alveolar epithelial cells. *BMC Complement Altern Med.* 2013; 13(1): 1-8.
35. Fuglie LJ. The *Moringa* Tree: A local solution to malnutrition. Red-moringa. 2005.
36. Monera TG, Maponga CC. Prevalence and patterns of *Moringa oleifera* use among HIV positive patients in Zimbabwe: A cross-sectional survey. *J Public Health Afr.* 2012; 3(1): 6-8.
37. Rockwood JL, Anderson BG, Casamatta DA. Potential uses of *Moringa oleifera* and an examination of antibiotic efficacy conferred by *M. oleifera* seed and leaf extracts using crude extraction techniques available to underserved indigenous populations. *Int J Phytother Res.* 2013; 3(2): 61-71.
38. Popoola JO, Obembe OO. Local knowledge, use pattern and geographical distribution of *Moringa oleifera* Lam. (Moringaceae) in Nigeria. *J Ethnopharmacol.* 2013; 150(2): 682-691.
39. Yabesh JM, Prabhu S, Vijayakumar S. An ethnobotanical study of medicinal plants used by traditional healers in silent valley of Kerala, India. *J Ethnopharmacol.* 2014; 154(3): 774-789.
40. Dori GU, Yerbanga SR, Tepongning NR, Lucantoni L, Lupidi G, Deresa W, et al. Contributing to the validation of *Moringa stenopetala* an antimalarial plant widely used in Southern Ethiopia. *Italian Society for parasitology.* 2010; 1(2): 221.
41. Demeulenaere E. *Moringa stenopetala*, a subsistence resource in the Konso district. *Proceedings of the International Development potential for *Moringa* products.* 2001; 29.
42. Seid MA. Medicinal and dietary role of *Moringa stenopetala* (Bak. f.) Cuf. South Ethiopia: A Review. *African J Agric Sci Technol.* 2013; 1(1): 1-6.
43. Mekonnen Y, Yardley V, Rock P, Croft S. *In vitro* antitypanosomal activity of *Moringa stenopetala* leaves and roots. *Phytother Res.* 1999; 13(6): 538-539.
44. Bosch CH. *Moringa stenopetala* (Baker f.) Cufod. *Vegetables/Légumes.* 2004; 395-397.
45. Jahn SA. The traditional domestication of a multipurpose tree *Moringa stenopetala* (Bak. f.) Cuf. in the Ethiopian Rift Valley. *Ambio.* 1991; 244-247.
46. Mekonnen Y. The multi-purpose *Moringa* tree: Ethiopia. Examples of the development of pharmaceutical products from medicinal plants. *2002;* 10: 111-118.
47. Mekonnen Y, Gessesse A. Documentation on the uses of *Moringa stenopetala* and its possible antileishmanial and antifertility effects. *SINET: Ethiop J Sci.* 1998; 21(2): 287-295.
48. Boulos L. Flora of Egypt. The Heritage of Egypt. 2000; 1: 238.
49. Miller AG, Morris M. Plants of Dhofar (The southern region of Oman; traditional, economic and medicinal uses). The office of the Adviser for Conservation of the Environment, Diwan of Royal Court, Sultanate of Oman. *J Trop Ecol.* 1990; 6(1): 102.
50. Elbatran SA, Abdel-Salam OM, Abdelshfeek KA, Nazif NM, Ismail SI, Hammouda FM. Phytochemical and pharmacological investigations on *Moringa peregrina* (Forssk) Fiori. *Nat Prod Sci.* 2005; 11(4): 199-206.
51. Nawash OS, Ahmad Al-S H. The most important medicinal plants in Wadi Araba desert in South West Jordan: A review article. *Adv Environ Biol.* 2011; 5(2): 418-426.
52. Ayyari M, Salehi P, Ebrahimi SN, Zimmermann S, Portmann L, Krauth-Siegel RL, et al. Antitypanosomal isothiocyanate and thiocarbamate glycosides from *Moringa peregrina*. *Planta Med.* 2014; 80(1): 86-89.
53. Subramanian N. Pharmacognostical and phytochemical investigations of *Moringa concanensis* (Moringaceae) an ethno medicine of Nilgiris. *J Pharmacognosy Phytother.* 2009; 1(6): 76-81.
54. Jayabharathi M, Chitra M. Evaluation of anti-inflammatory, analgesic and antipyretic activity of *Moringa concanensis* Nimmo. *J Chem Pharm Res.* 2011; 3(2): 802-806.
55. Anbazhakan S, Dhandapani R, Anandhakumar P, Balu S. Traditional medicinal knowledge on *Moringa concanensis* Nimmo of perambalur District, Tamilnadu. *Anc Sci Life.* 2007; 26(4): 42.
56. Shantanu K, Gunratna G, Nakul C. Formulation and *in vitro* evaluation of *Moringa concanensis*, Nimmo. seed oils sunscreen cream. *Int J Pharmtech Res.* 2010; 2(3): 2060-2062.

57. Berushka P, Himansu B. An overview of the medicinal importance of Moringaceae. *J Med Plants Res.* 2012; 6(48): 5831-5839.
58. Thulin M. *Moringa pygmaea* Verdc. (Family: Moringaceae). *Flora Somalia.* 2012.
59. Odee DW, Muluvi GM, Machua J, Olson ME, Changwony M. Domestication of *Moringa* species in Kenya, development potential for *Moringa* products. *Workshop proceedings.* 2001.
60. Faizi S, Siddiqui BS, Saleem R, Siddiqui S, Aftab K, Gilani AU. Isolation and structure elucidation of new nitrile and mustard oil glycosides from *Moringa oleifera* and their effect on blood pressure. *J Nat Prod.* 1994; 57(9): 1256-1261.
61. Saluja MP, Kapil RS, Popli SP. Studies in medicinal plant: Part IV chemical constituents of *Moringa oleifera* Lam., (Hybrid variety) and isolation of 4-hydroxymellein. *Indian J Chem.* 1978; 16: 1044-1045.
62. Bhattacharya SB, Das AK, Banerji N. Chemical investigations on the gum exudate from sajna (*Moringa oleifera*). *Carbohydr Res.* 1982; 102(1): 253-262.
63. Khare GC, Singh V, Gupta PC. A new Leucoanthocyanin from *Moringa oleifera* Gum. *J Indian Chem Soc.* 1997; 74: 247-248.
64. Ruckmani K, Kavimani S, An R, Jaykar B. Effect of *Moringa oleifera* Lam on paracetamol-induced hepatotoxicity. *Indian J Pharm Sci.* 1998; 60(1): 33.
65. Pramanik A, Islam SS. Chemical investigation of aqueous extract of the mature and premature flowers of *Moringa oleifera* (Sajina) and structural studies of a polysaccharide isolated from its premature flowers. *Indian J Chem.* 1998; 37: 676-682.
66. Faizi S, Siddiqui BS, Saleem R, Aftab K, Shaheen F. Hypotensive constituents from the pods of *Moringa oleifera*. *Planta Med.* 1998; 64(03): 225-228.
67. Faizi S, Siddiqui BS, Saleem R, Siddiqui S, Aftab K. Fully acetylated carbamate and hypotensive thiocarbamate glycosides from *Moringa oleifera*. *Phytochemistry.* 1995; 38(4): 957-963.
68. Nagar PK, Iyer RI, Sircar PK. Cytokinins in developing fruits of *Moringa pterigosperma* Gaertn. *Physiologia plantarum.* 1982; 55(1): 45-50.
69. Cheenpracha S, Park EJ, Yoshida WY, Barit C, Wall M, Pezzuto JM, et al. Potential anti-inflammatory phenolic glycosides from the medicinal plant *Moringa oleifera* fruits. *Bioorg Med Chem.* 2010; 18(17): 6598-6602.
70. Siddharaju P, Becker K. Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. *J Agric Food Chem.* 2003; 51(8): 2144-2155.
71. Makkar HA, Becker K. Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. *Anim Feed Sci Technol.* 1996; 63(1-4): 211-228.
72. Ramachandran C, Peter KV, Gopalakrishnan PK. Drumstick (*Moringa oleifera*): A multipurpose Indian vegetable. *Econ Bot.* 1980; 34: 276-283.
73. Price M. The *Moringa* tree. Educational Concerns for Hunger Organization (ECHO). 1985.
74. Pallavi J, Dipika M. Effect of dehydration on the nutritive value of drumstick leaves. *J Metabolomics Syst Biol.* 2010; 1(1): 5-9.
75. Moyo B, Masika PJ, Hugo A, Muchenje V. Nutritional characterization of *Moringa* (*Moringa oleifera* Lam.) leaves. *Afr J Biotechnol.* 2011; 10(60): 12925-12933.
76. Min Z, Navam SH, Ronny H, Arvind K, Apputhury PM, Arumugam M, et al. Phytochemicals, antioxidant and antimicrobial activity of *Hibiscus sabdariffa*, *Centella asiatica*, *Moringa oleifera* and *Murraya koenigii* leaves. *J Med Plants Res.* 2011; 5(30): 6672-6680.
77. Prakash D, Suri S, Upadhyay G, Singh BN. Total phenol, antioxidant and free radical scavenging activities of some medicinal plants. *Int J Food Sci Nutr.* 2007; 58(1): 18-28.
78. Verma AR, Vijayakumar M, Mathela CS, Rao CV. *In vitro* and *in vivo* antioxidant properties of different fractions of *Moringa oleifera* leaves. *Food Chem Toxicol.* 2009; 47(9): 2196-2201.
79. Bennett RN, Mellon FA, Foidl N, Pratt JH, Dupont MS, Perkins L, et al. Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees *Moringa oleifera* L.(horse-radish tree) and *Moringa stenopetala* L. *J Agric Food Chem.* 2003; 51(12): 3546-3553.
80. Leuck M, Kunz H. Synthesis of active principles from the leaves of *Moringa oleifera* using S-pent-4-enyl thioglycosides. *Carbohydr Res.* 1998; 312(1-2): 33-44.
81. Manguro LO, Lemmen P. Phenolics of *Moringa oleifera* leaves. *Nat Prod Res.* 2007; 21(1): 56-68.
82. Atawodi SE, Atawodi JC, Idakwo GA, Pfundstein B, Haubner R, Wurtele G, et al. Evaluation of the polyphenol content and antioxidant properties of methanol extracts of the leaves, stem, and root barks of *Moringa oleifera* Lam. *J Med Food.* 2010; 13(3): 710-716.
83. Oluduro OA, Aderiye BI, Connolly JD, Akintayo ET, Famurewa O. Characterization and antimicrobial activity of 4-(β-D-glucopyranosyl-1→ 4-α-L-rhamnopyranosyloxy)-benzyl thiocarboxamide: A novel bioactive compound from *Moringa oleifera* seed extract. *Folia Microbiol.* 2010; 55(5): 422-426.
84. Oliveira JT, Silveira SB, Vasconcelos IM, Cavada BS, Moreira RA. Compositional and nutritional attributes of seeds from the multiple purpose tree *Moringa oleifera* Lamarck. *J. Sci Food Agric.* 1999; 79(6): 815-820.
85. Kær A, Malver O, El-Menshawi B, Reisch J. Isothiocyanates in myrosinase-treated seed extracts of *Moringa peregrina*. *Phytochemistry.* 1979; 18(9): 1485-1487.
86. Dahot MU, Memon AR. Nutritive significance of oil extracted from *Moringa oleifera* seeds. *J Pharm Univ Karachi.* 1985; 3(2): 75-80.
87. Aja PM, Nwachukwu N, Ibiam UA, Igwenyi IO, Offor CE, Orji UO. Chemical constituents of *Moringa oleifera* leaves and seeds from Abakaliki, Nigeria. *American Journal of Phytomedicine and Clinical Therapeutics.* 2014; 2(3): 310-321.
88. Memon GM, Khatri LM. Isolation and spectroscopic studies of mono-palmitic, dioleic triglyceride from seeds of *Moringa oleifera* Lam. *Pak J Sci Ind Res.* 1987; 30(5): 393-395.
89. Anwar F, Bhanger MI. Analytical characterization of *Moringa oleifera* seed oil grown in temperate regions of Pakistan. *J Agric Food Chem.* 2003; 51(22): 6558-6563.
90. Faizi S, Siddiqui BS, Saleem R, Siddiqui S, Aftab K. Novel hypotensive agents, niazimin A, niazimin B, niazicin A and niazicin B from *Moringa oleifera*: Isolation of first naturally occurring carbamates. *J Chem Soc Perkin Trans I.* 1994; 20: 3035-3040.
91. Lalas S, Tsaknis J. Extraction and identification of natural antioxidant from the seeds of the *Moringa oleifera* tree variety of Malawi. *J Am Oil Chem Soc.* 2002; 79(7): 677-683.
92. Vlahov G, Chepkwony PK, Ndalut PK. <sup>13</sup>C NMR characterization of triacylglycerols of *Moringa oleifera* seed oil: An "oleic-vaccenic acid" oil. *J Agric Food Chem.* 2002; 50(5): 970-975.

93. Nikkon F, Saud ZA, Rahman MH, Haque ME. *In vitro* antimicrobial activity of the compound isolated from chloroform extract of *Moringa oleifera* Lam. Pak J Biol Sci. 2003; 6(22): 1888-1890.
94. Sashidhara KV, Rosaiah JN, Tyagi E, Shukla R, Raghbir R, Rajendran SM. Rare dipeptide and urea derivatives from roots of *Moringa oleifera* as potential anti-inflammatory and antinociceptive agents. Eur J Med Chem. 2009; 44(1): 432-436.
95. Amaglo NK, Bennett RN, Curto RB, Rosa EA, Turco VL, Giuffrida A, et al. Profiling selected phytochemicals and nutrients in different tissues of the multipurpose tree *Moringa oleifera* L., grown in Ghana. Food Chem. 2010; 122(4): 1047-1054.
96. Mekonnen Y, Dräger B. Glucosinolates in *Moringa stenopetala*. Planta Med. 2003; 69(04): 380-382.
97. Mekonen A, Gebreyesus T. Chemical investigation of the leaves of *Moringa stenopetala*. Bull Chem Soc Ethiop. 2000; 14(1).
98. Nibret E, Wink M. Trypanocidal and antileukaemic effects of the essential oils of *Hagenia abyssinica*, *Leonotis ocymifolia*, *Moringa stenopetala*, and their main individual constituents. Phytomedicine. 2010; 17(12): 911-920.
99. Abuye C, Urga K, Knapp H, Selmar D, Omwega AM, Imungi JK, et al. A compositional study of *Moringa stenopetala* leaves. East Afr Med J. 2003; 80(5): 247-252.
100. Toma A, Makonnen E, Mekonnen Y, Debella A, Addisakwattana S. Intestinal α-glucosidase and some pancreatic enzymes inhibitory effect of hydroalcoholic extract of *Moringa stenopetala* leaves. BMC Complement Altern Med. 2014; 14(1): 1-5.
101. Melesse A. Comparative assessment on chemical compositions and feeding values of leaves of *Moringa stenopetala* and *Moringa oleifera* using *in vitro* gas production method. Ethiop J Appl Sci Technol. 2011; 2(2): 29-38.
102. Geleta B, Makonnen E, Debella A, Tadele A. *In vivo* antihypertensive and antihyperlipidemic effects of the crude extracts and fractions of *Moringa stenopetala* (Baker f.) Cufod. leaves in rats. Front Pharmacol. 2016; 7: 97.
103. Bekele B, Adane L, Tariku Y, Hailu A. Evaluation of antileishmanial activities of triglycerides isolated from roots of *Moringa stenopetala*. Med Chem Res. 2013; 22(10): 4592-4599.
104. Lalas S, Tsaknis J, Sfomos K. Characterisation of *Moringa stenopetala* seed oil variety "Marigat" from island Kokwa. Eur J Lipid Sci Technol. 2003; 105(1): 23-31.
105. Yisehak K, Solomon M, Tadelle M. Contribution of *Moringa* (*Moringa stenopetala*, Bac.), a highly nutritious vegetable tree, for food security in south Ethiopia: A review. Asian J Appl Sci. 2011; 4(5): 477-488.
106. Tesemma M, Adane L, Tariku Y, Muleta D, Demise S. Isolation of compounds from acetone extract of root wood of *Moringa stenopetala* and evaluation of their antibacterial activities. Res J Med Plant. 2013; 7(1): 32-47.
107. Mengistu M. Hypotensive effects of aqueous extract of *Moringa stenopetala* in both *in vivo* and *in vitro* animal models. Addis Ababa University. 2007.
108. Melesse A, Bulang M, Kluth H. Evaluating the nutritive values and *in vitro* degradability characteristics of leaves, seeds and seedpods from *Moringa stenopetala*. J Sci Food Agric. 2009; 89(2): 281-287.
109. Tsaknis J. Characterisation of *Moringa peregrina* Arabia seed oil. Grasas Aceites. 1998; 49(2): 170-176.
110. El-Alfy TS, Ezzat SM, Hegazy AK, Amer AM, Kamel GM. Isolation of biologically active constituents from *Moringa peregrina* (Forssk.) Fiori.(family: Moringaceae) growing in Egypt. Pharmacogn Mag. 2011; 7(26): 109.
111. Tahany MA, Hegazy AK, Sayed AM, Kabel HF, El-Alfy T, El-Komy SM. Study on combined antimicrobial activity of some biologically active constituents from wild *Moringa peregrina* Forssk. J Yeast Fungal Res. 2010; 1(1): 15-24.
112. Osman HE, Abohassan AA. Morphological and analytical characterization of *Moringa peregrina* populations in western Saudi Arabia. Int J Theor Appl Sci. 2012; 4(2): 174-184.
113. Al-Dabbas MM, Ahmad RA, Ajo RY, Abulaila KH, Akash MU, Al-Ismail KH. Chemical composition and oil components in seeds of *Moringa peregrina* (Forssk) Fiori. Crop Res. 2010; 40(1): 2.
114. Somali MA, Bajneid MA, Al-Fhaimani SS. Chemical composition and characteristics of *Moringa peregrina* seeds and seeds oil. J Am Oil Chem Soc. 1984; 61(1): 85-86.
115. Abd-El-baky HH, El-Baroty GS. Characterization of Egyptian *Moringa peregrine* seed oil and its bioactivities. Int J Manage Sci Bus Res. 2013; 2: 98-108.
116. Afsharypuor S, Asghari G, Mohagheghzadeh A, Dehshahri S. Volatile constituents of the seed kernel and leaf of *Moringa peregrina* (Forssk.) Fiori, Agricolt. Cultivated in Chabahar (Iran). Iran J Pharm Sci. 2010; 6(2): 141-144.
117. Dehshahri SH, Wink M, Afsharypuor S, Asghari G, Mohagheghzadeh A. Antioxidant activity of methanolic leaf extract of *Moringa peregrina* (Forssk.) Fiori. Res Pharm Sci. 2012; 7(2): 111.
118. Dehshahri S, Afsharypuor S, Asghari G, Mohagheghzadeh A. Determination of volatile glucosinolate degradation products in seed coat, stem and *in vitro* cultures of *Moringa peregrina* (Forssk.) Fiori. Res Pharm Sci. 2012; 7(1): 51.
119. Al-Owaisi M, Al-Hadiwi N, Khan SA. GC-MS analysis, determination of total phenolics, flavonoid content and free radical scavenging activities of various crude extracts of *Moringa peregrina* (Forssk.) Fiori leaves. Asian Pac J Trop Biomed. 2014; 4(12): 964-970.
120. Manzoor M, Anwar F, Iqbal T, Bhanger MI. Physico-chemical characterization of *Moringa concanensis* seeds and seed oil. J Am Oil Chem Soc. 2007; 84(5): 413-419.
121. Verma SC, Banerji R, Misra G, Nigam SK. Nutritional value of *Moringa*. Curr Sci. 1976; 45: 769-770.
122. Jayabharathi M, Chitra M. Evaluation of anti-inflammatory, analgesic and antipyretic activity of *Moringa concanensis* Nimmo. J Chem Pharm Res. 2011; 3(2): 802-806.
123. Ravichandran V, Arunachalam G, Subramanian N, Suresh B. Pharmacognostical and phytochemical investigations of *Moringa concanensis* (Moringaceae) an ethno medicine of Nilgiris. J Pharmacog Phytother. 2009; 1(6): 76-81.
124. Megha G, Shantanu K, Snehal B, Vaibhav U, Amol R. Extraction, characterization and comparison of fixed oil of *Moringa oleifera* L and *Moringa concanensis* Nimmo Fam. Moringaceae. Int J Pharm Tech Res. 2011; 3(3): 1567-1575.
125. Santhi K, Sengottuvvel R. Qualitative and quantitative phytochemical analysis of *Moringa concanensis* Nimmo. Int J Current Microbiol App Sci. 2016; 5(1): 633-640.
126. Balamurugan V, Balakrishnan V. Evaluation of phytochemical, Pharmacognostical and antimicrobial activity from the bark of *Moringa concanensis* Nimmo. Int J Curr Microbiol App Sci. 2013; 2(4): 117-125.

127. Bhamadevi R. Screening of Bioactive Compounds from the leaves of *Moringa concanensis* Nimmo. Int J Innov Res Sci Eng Technol. 2015; 4: 9702.
128. Balamurugan V, Balakrishnan V. Preliminary phytochemicals, pharmacognostic evaluation and antimicrobial activity of *Moringa concanensis* nimmo leaf. Global J Bio-Sci Biotechnol. 2013; 2: 243-247.
129. Chandrasekar S, Malathi R. Identification of bioactive constituents in *Moringa concanensis* leaf using gas chromatography and mass spectrometry. Int J Curr Adv Res. 2016; 5: 1071-1073.
130. Balamurugan V, Balakrishnan V, Sundaresan A. GC-MS analysis of leaf and bark extract of *Moringa concanensis* Nimmo, a siddha medicinal plant of South India. Eur J Biotechnol Biosci. 2015; 3(12): 57-61.
131. Ugarte-Barco F, Morales KA, Bernal CM. Estudios preliminares del efecto fortificante de extractos de *Moringa oleifera* Lam. en vitoplatas del clon Williams en aclimatación. Revista Científica Agroecosistemas. 2018; 6(2): 47-55.
132. Coppin J. A study of the nutritional and medicinal values of *Moringa oleifera* leaves from sub-Saharan Africa: Ghana, Rwanda, Senegal and Zambia. Rutgers University. 2008.
133. Mukunzi D, Nsor-Atindana J, Xiaoming Z, Gahungu A, Karangwa E, Mukamurezi G, et al. Comparison of volatile profile of *Moringa oleifera* leaves from Rwanda and China using HS-SPME. Pakistan J Nutr. 2011; 10(7): 602-608.
134. Parvathy MV, Umamaheshwari A. Cytotoxic effect of *Moringa oleifera* leaf extracts on human multiple myeloma cell lines. Trends Med Res. 2007; 2(1): 44-50.
135. Masood MK. Evaluation of anticancer activity of *Moringa oleifera* L. on EAC bearing mice. Hanagal Shri Kumareshwa College of Pharmacy. 2010.
136. Sreelatha S, Padma PR. Antioxidant activity and total phenolic content of *Moringa oleifera* leaves in two stages of maturity. Plant Foods Hum Nutr. 2009; 64(4): 303-311.
137. Gupta A, Gautam MK, Singh RK, Kumar MV, Rao CV, Goel RK, et al. Immunomodulatory effect of *Moringa oleifera* Lam. extract on cyclophosphamide induced toxicity in mice. Indian J Exp Biol. 2010; 48: 1157-1160.
138. Sudha P, Asdaq SM, Dhamingi SS, Chandrakala GK. Immunomodulatory activity of methanolic leaf extract of *Moringa oleifera* in animals. Indian J Physiol Pharmacol. 2010; 54(2): 133-140.
139. Sulaiman MR, Zakaria ZA, Bujarimin AS, Somchit MN, Israf DA, Moin S. Evaluation of *Moringa oleifera* aqueous extract for antinociceptive and anti-inflammatory activities in animal models. Pharmacol Biol. 2008; 46(12): 838-845.
140. Mahajan SG, Mehta AA. Curative effect of hydroalcoholic extract of leaves of *Moringa oleifera* lam. against adjuvant induced established arthritis in rats. Niger J Nat Prod Med. 2009; 13: 13-22.
141. Mahajan SG, Mehta AA. Immunosuppressive activity of ethanolic extract of seeds of *Moringa oleifera* Lam. in experimental immune inflammation. J Ethnopharmacol. 2010; 130(1): 183-186.
142. Muangnoi C, Chingsuwanrote P, Praengamthanachoti P, Svasti S, Tuntipopipat S. *Moringa oleifera* pod inhibits inflammatory mediator production by lipopolysaccharide-stimulated RAW 264.7 murine macrophage cell lines. Inflammation. 2012; 35(2): 445-455.
143. Jaiswal D, Rai PK, Kumar A, Mehta S, Watal G. Effect of *Moringa oleifera* Lam. leaves aqueous extract therapy on hyperglycemic rats. J Ethnopharmacol. 2009; 123(3): 392-396.
144. Ndong M, Uehara M, Katsumata SI, Suzuki K. Effects of oral administration of *Moringa oleifera* Lam. on glucose tolerance in Goto-Kakizaki and Wistar rats. J Clin Biochem Nutr. 2007; 40(3): 229-233.
145. Ghasi S, Nwobodo E, Ofili JO. Hypocholesterolemic effects of crude extract of leaf of *Moringa oleifera* Lam. in high-fat diet fed Wistar rats. J Ethnopharmacol. 2000; 69(1): 21-25.
146. Jain PG, Patil SD, Haswani NG, Girase MV, Surana SJ. Hypolipidemic activity of *Moringa oleifera* Lam., Moringaceae, on high fat diet induced hyperlipidemia in Albino rats. Rev Bras Farmacogn. 2010; 20: 969-973.
147. Divi SM, Bellamkonda RA, Dasireddy SK. Evaluation of antidiabetic and antihyperlipidemic potential of aqueous extract of *Moringa oleifera* in fructose fed insulin resistant and STZ induced diabetic wistar rats: A comparative study. Asian J Pharm Clin Res. 2012; 5(1): 67-72.
148. Al-Malki AL, El Rabey HA. The antidiabetic effect of low doses of *Moringa oleifera* Lam. seeds on streptozotocin induced diabetes and diabetic nephropathy in male rats. Biomed Res Int. 2015.
149. Kirisattayakul W, Wattanathorn J, Tong-Un T, Muchimapura S, Wan-nanon P, Jittiwat J. Cerebroprotective effect of *Moringa oleifera* against focal ischemic stroke induced by middle cerebral artery occlusion. Oxid Med Cell Longev. 2013.
150. Chuang PH, Lee CW, Chou JY, Murugan M, Shieh BJ, Chen HM. Anti-fungal activity of crude extracts and essential oil of *Moringa oleifera* Lam. Bioresour Technol. 2007; 98(1): 232-236.
151. Sutalangka C, Wattanathorn J, Muchimapura S, Thukham-mee W. *Moringa oleifera* mitigates memory impairment and neurodegeneration in animal model of age-related dementia. Oxid Med Cell Longev. 2013.
152. Adeyemi OS, Elebiyo TC. *Moringa oleifera* supplemented diets prevented nickel-induced nephrotoxicity in wistar rats. J Nutr Metab. 2014.
153. Bakre AG, Aderibigbe AO, Ademowo OG. Studies on neuropharmacological profile of ethanol extract of *Moringa oleifera* leaves in mice. J Ethnopharmacol. 2013; 149(3): 783-789.
154. Ingale SP, Gandhi FP. Effect of aqueous extract of *Moringa oleifera* leaves on pharmacological models of epilepsy and anxiety in mice. Int J Epilepsy. 2016; 3(1): 12-19.
155. Choudhary MK, Bodakhe SH, Gupta SK. Assessment of the antiulcer potential of *Moringa oleifera* root-bark extract in rats. J Acupunct Meridian Stud. 2013; 6(4): 214-220.
156. Mahajan SG, Mehta AA. Anti-arthritis activity of hydroalcoholic extract of flowers of *Moringa oleifera* lam. in wistar rats. J Herbs Spices Med Plants. 2009; 15(2): 149-163.
157. Viera GH, Mourão JA, Ângelo ÂM, Costa RA, Vieira RH. Antibacterial effect (*in vitro*) of *Moringa oleifera* and *Annona muricata* against Gram positive and Gram negative bacteria. Rev Inst Med Trop Sao Paulo. 2010; 52: 129-132.
158. Nair S, Varalakshmi KN. Anticancer, cytotoxic potential of *Moringa oleifera* extracts on HeLa cell line. J Nat Pharm. 2011; 2(3): 138-142.
159. Abalaka ME, Daniyan SY, Oyeleke SB, Adeyemo SO. The antibacterial evaluation of *Moringa oleifera* leaf extracts on selected bacterial pathogens. J Microbiol Res. 2012; 2(2): 1-4.
160. Bharali R, Tabassum J, Azad MR. Chemomodulatory effect of *Moringa oleifera* Lam. on hepatic carcinogen metabolising enzymes, antioxidant parameters and skin papillomagenesis in mice. Asian Pac J Cancer Prev. 2003; 4(2): 131-140.

161. Mehta K, Balaraman R, Amin AH, Bafna PA, Gulati O. Effect of fruits of *Moringa oleifera* on the lipid profile of normal and hypercholesterolaemic rabbits. *J Ethnopharmacol.* 2003; 86(3): 191-195.
162. Thilza IB, Sanni S, Isah Z, Sanni F, Talle M, Joseph M. *In vitro* anti-microbial activity of water extract of *Moringa oleifera* leaf stalk on bacteria normally implicated in eye diseases. *Acad Arena.* 2010; 2(6): 80-82.
163. Paliwal R, Sharma V, Pracheta SS, Yadav S, Sharma S. Anti-nephro-toxic effect of administration of *Moringa oleifera* Lam in amelioration of DMBA-induced renal carcinogenesis in Swiss albino mice. *Bio Med.* 2011; 3(2): 27-35.
164. Sutar NG, Patil VV, Deshmukh TA, Jawle Sr NM, Patil Sr VR, Bhangale SC. Evaluation of anti-pyretic potential of seeds of *Moringa oleifera* Lam. *Int J Green Pharm.* 2009; 3(2).
165. Mahajan SG, Banerjee A, Chauhan BF, Padh H, Nivsarkar M, Mehta AA. Inhibitory effect of n-butanol fraction of *Moringa oleifera* Lam. seeds on ovalbumin-induced airway inflammation in a guinea pig model of asthma. *Int J Toxicol.* 2009; 28(6): 519-527.
166. Agrawal B, Mehta A. Antiasthmatic activity of *Moringa oleifera* Lam: A clinical study. *Indian J Pharmacol.* 2008; 40(1): 28.
167. Mahajan SG, Mali RG, Mehta AA. Protective effect of ethanolic extract of seeds of *Moringa oleifera* Lam. against inflammation associated with development of arthritis in rats. *J Immunotoxicol.* 2007; 4(1): 39-47.
168. Rathi BS, Bodhankar SL, Baheti AM. Evaluation of aqueous leaves extract of *Moringa oleifera* Linn for wound healing in albino rats. *Indian J Exp Biol.* 2006; 44(11): 898-901.
169. Hukkeri VI, Nagathan CV, Karadi RV, Patil BS. Antipyretic and wound healing activities of *Moringa oleifera* Lam. in rats. *Indian J Pharm Sci.* 2006; 68(1): 124.
170. Tahiliani P, Kar A. Role of *Moringa oleifera* leaf extract in the regulation of thyroid hormone status in adult male and female rats. *Pharmacol Res.* 2000; 41(3): 319-323.
171. Caceres A, Cabrera O, Morales O, Mollinedo P, Mendia P. Pharmacological properties of *Moringa oleifera*. 1: Preliminary screening for antimicrobial activity. *J Ethnopharmacol.* 1991; 33(3): 213-216.
172. Ayanbimpe GM, Ojo TK, Afolabi E, Opara F, Orsaah S, Ojerinde OS. Evaluation of extracts of *Jatropha curcas* and *Moringa oleifera* in culture media for selective inhibition of saprophytic fungal contaminants. *J Clin Lab Anal.* 2009; 23(3): 161-164.
173. Lürling M, Beekman W. Anti-cyanobacterial activity of *Moringa oleifera* seeds. *J Appl Phycol.* 2010; 22(4): 503-510.
174. Hamza AA. *Curcuma longa*, *Glycyrrhiza glabra* and *Moringa oleifera* ameliorate Diclofenac-induced hepatotoxicity in rats. *Am J Pharm Toxicol.* 2007; 2(2): 80-88.
175. Pari L, Kumar NA. Hepatoprotective activity of *Moringa oleifera* on antitubercular drug-induced liver damage in rats. *J Med Food.* 2002; 5(3): 171-177.
176. Selvakumar D, Natarajan P. Hepato-protective activity of *Moringa oleifera* lam leaves in Carbon tetrachloride induced hepato-toxicity in albino rats. *Pharmacogn Mag.* 2008; 4(13): 97.
177. Fakurazi S, Hairuszah I, Nanthini U. *Moringa oleifera* Lam prevents acetaminophen induced liver injury through restoration of glutathione level. *Food Chem Toxicol.* 2008; 46(8): 2611-2615.
178. Fakurazi S, Sharifudin SA, Arulselvan P. *Moringa oleifera* hydro-ethanolic extracts effectively alleviate acetaminophen-induced hepatotoxicity in experimental rats through their antioxidant nature. *Molecules.* 2012; 17(7): 8334-8350.
179. Hamza AA. Ameliorative effects of *Moringa oleifera* Lam seed extract on liver fibrosis in rats. *Food Chem Toxicol.* 2010; 48(1): 345-355.
180. Rao AV, Devi PU, Kamath R. *In vivo* radioprotective effect of *Moringa oleifera* leaves. *Indian J Exp Biol.* 2001; 39(9): 858-863.
181. Akhtar AH, Ahmad KU. Anti-ulcerogenic evaluation of the methanolic extracts of some indigenous medicinal plants of Pakistan in aspirin-ulcerated rats. *J Ethnopharmacol.* 1995; 46(1): 1-6.
182. Gupta R, Kannan GM, Sharma M, Flora SJ. Therapeutic effects of *Moringa oleifera* on arsenic-induced toxicity in rats. *Environ Toxicol Pharmacol.* 2005; 20(3): 456-464.
183. Nandave M, Ojha SK, Joshi S, Kumari S, Arya DS. *Moringa oleifera* leaf extract prevents isoproterenol-induced myocardial damage in rats: Evidence for an antioxidant, antiperoxidative, and cardioprotective intervention. *J Med Food.* 2009; 12(1): 47-55.
184. Sharma V, Paliwal R, Janmeda P, Sharma S. Renoprotective effects of *Moringa oleifera* pods in 7, 12 dimethylbenz [a] anthracene exposed mice. *J Chin Int Med.* 2012; 10: 1171-1178.
185. Manaheji H, Jafari S, Zaringhalam J, Rezazadeh S, Taghizadfarid R. Analgesic effects of methanolic extracts of the leaf or root of *Moringa oleifera* on complete Freund's adjuvant-induced arthritis in rats. *J Chin Int Med.* 2011; 9(2): 216-222.
186. Sinha M, Das DK, Bhattacharjee S, Majumdar S, Dey S. Leaf extract of *Moringa oleifera* prevents ionizing radiation-induced oxidative stress in mice. *J Med Food.* 2011; 14(10): 1167-1172.
187. Pereira ML, de Oliveira HD, de Oliveira JTA, Gifoni JM, de Oliveira RR, de Sousa DOB, et al. Purification of a chitin-binding protein from *Moringa oleifera* seeds with potential to relieve pain and inflammation. *Protein Pept Lett.* 2011; 18(11): 1078-1085.
188. Satish A, Sairam S, Ahmed F, Urooj A. *Moringa oleifera* Lam.: Protease activity against blood coagulation cascade. *Pharmacognosy Res.* 2012; 4(1): 44.
189. Luqman S, Srivastava S, Kumar R, Maurya AK, Chanda D. Experimental assessment of *Moringa oleifera* leaf and fruit for its antistress, antioxidant, and scavenging potential using *in vitro* and *in vivo* assays. *Evid Based Complement Alternat Med.* 2012.
190. Moyo B, Oyedemi S, Masika PJ, Muchenje V. Polyphenolic content and antioxidant properties of *Moringa oleifera* leaf extracts and enzymatic activity of liver from goats supplemented with *Moringa oleifera* leaves/sunflower seed cake. *Meat Sci.* 2012; 91(4): 441-447.
191. Gupta R, Mathur M, Bajaj VK, Katariya P, Yadav S, Kamal R, et al. Evaluation of antidiabetic and antioxidant activity of *Moringa oleifera* in experimental diabetes. *J Diabetes.* 2012; 4(2): 164-171.
192. Gupta SK, Kumar B, Srinivasan BP, Nag TC, Srivastava S, Saxena R, et al. Retinoprotective effects of *Moringa oleifera* via antioxidant, anti-inflammatory, and anti-angiogenic mechanisms in streptozotocin-induced diabetic rats. *J Ocul Pharmacol Ther.* 2013; 29(4): 419-426.
193. Momoh MA, Chime SA, Kenechukwu FC. Novel drug delivery system of plant extract for the management of diabetes: An antidiabetic study. *J Diet Suppl.* 2013; 10(3): 252-263.
194. Ouédraogo M, Lamien-Sanou A, Ramdé N, Ouédraogo AS, Ouédraogo M, Zongo SP, et al. Protective effect of *Moringa oleifera* leaves against gentamicin-induced nephrotoxicity in rabbits. *Exp Toxicol Pathol.* 2013; 65(3): 335-339.
195. Guo L, Fuscoe J, Fu P, Mei N. Application of DNA microarray in studies of herbal dietary supplements. *Handbook of systems toxicology.* 2010: 407-418.

196. Ruan J, Gao H, Li N, Xue J, Chen J, Ke C, et al. Blood pyrrole-protein adducts-a biomarker of pyrrolizidine alkaloid-induced liver injury in humans. *J Environ Sci Health C Environ Carcinog Ecotoxicol Rev.* 2015; 33(4): 404-421.
197. Goldberg DS, Forde KA, Carbonari DM, Lewis JD, Leidl KB, Reddy KR, et al. Population-representative incidence of drug-induced acute liver failure based on an analysis of an integrated health care system. *Gastroenterology.* 2015; 148(7): 1353-1361.
198. Ayotunde EO, Fagbenro OA, Adebayo OT, Amoo AI. Toxicity of Aqueous Extracts of Drumstick, *Moringa oleifera*, Seeds to Nile tilapia, *Oreochromis niloticus*, Fingerlings and Adults. *Int Res J Agric Sci Soil Sci.* 2011; 1(4): 142-150.
199. Adedapo AA, Mogbojuri OM, Emikpe BO. Safety evaluations of the aqueous extract of the leaves of *Moringa oleifera* in rats. *J Med Plant Res.* 2009; 3(8): 586-591.
200. Ajibade TO, Arowolo R, Olayemi FO. Phytochemical screening and toxicity studies on the methanol extract of the seeds of *Moringa oleifera*. *J Complement Integr Med.* 2013; 10(1): 11-16.
201. Asare GA, Gyan B, Bugyei K, Adjei S, Mahama R, Addo P, et al. Toxicity potentials of the nutraceutical *Moringa oleifera* at supra-supplementation levels. *J Ethnopharmacol.* 2012; 139(1): 265-272.
202. Ambi AA, Abdurahman EM, Katsayal UA, Sule MI, Patch UU, Ibrahim ND. Toxicity evaluation of *Moringa oleifera* leaves. *Int J Pharmaceut Res Innovat.* 2011; 4: 22-24.
203. Moodley I. Acute toxicity of *Moringa oleifera* leaf powder in rats. *J Med Plants Stud.* 2017; 5: 180-185.
204. Moodley I. Evaluation of sub chronic toxicity of *Moringa oleifera* leaf powder in mice. *J Toxicol Pharmacol.* 2018; 2: 19.
205. Awodele O, Oreagba IA, Odoma S, da Silva JA, Osunkalu VO. Toxicological evaluation of the aqueous leaf extract of *Moringa oleifera* Lam. (Moringaceae). *J Ethnopharmacol.* 2012; 139(2): 330-336.
206. Isitua CC, Ibeh IN. Toxicological assessment of aqueous extract of *Moringa oleifera* and *Caulis bambusae* leaves in rabbits. *J Clinic Toxicol.* 2013; 12: 4.
207. Oyagbemi AA, Omobowale TO, Azeez IO, Abiola JO, Adedokun RA, Nottidge HO. Toxicological evaluations of methanolic extract of *Moringa oleifera* leaves in liver and kidney of male Wistar rats. *J Basic Clin Physiol Pharmacol.* 2013; 24(4): 307-312.
208. Araújo LC, Aguiar JS, Napoleão TH, Mota FV, Barros AL, Moura MC, et al. Evaluation of cytotoxic and anti-inflammatory activities of extracts and lectins from *Moringa oleifera* seeds. *PloS One.* 2013; 8(12): e81973.
209. Rolim LA, Macêdo MF, Sisenando HA, Napoleão TH, Felzenszwalb I, Aiub CA, et al. Genotoxicity evaluation of *Moringa oleifera* seed extract and lectin. *J Food Sci.* 2011; 76(2): 53-58.
210. Asiedu-Gyekye IJ, Frimpong-Manso SA, Awortwe C, Antwi DA, Nyarko AK. Micro-and macroelemental composition and safety evaluation of the nutraceutical *Moringa oleifera* leaves. *J Toxicol.* 2014.
211. Mekonnen N, Houghton P, Timbrell J. The toxicity of extracts of plant parts of *Moringa stenopetala* in HEPG2 cells *in vitro*. *Phytother Res.* 2005; 19(10): 870-875.
212. Paul CW, Didia BC. The effect of methanolic extract of *Moringa oleifera* lam roots on the histology of kidney and liver of guinea pigs. *Asian J Med Sci.* 2012; 4(1): 55-60.
213. Musa A, Vata P, Debella A. Acute toxicity studies of butanol fraction of leaves of *Moringa stenopetala* in rats. *Asian Pac J Health Sci.* 2015; 2(2): 160-164.
214. Musa AH, Gebru G, Mekonnen Y, Debella A, Mekonnen E. Subchronic toxicity studies of butanol fraction of leaves of *Moringa stenopetala* in experimental rats. *Int J Curr Med Pharm Res.* 2015; 1(10): 170-175.
215. Ghebreselassie D, Mekonnen Y, Gebru G, Ergete W, Huruy K. The effects of *Moringa stenopetala* on blood parameters and histopathology of liver and kidney in mice. *Ethiop J Health Dev.* 2011; 25(1): 51-57.
216. Geleta B, Makonnen E, Debella A. Toxicological evaluations of the crude extracts and fractions of *Moringa stenopetala* leaves in liver and kidney of rats. *J Cytol Histol.* 2016; 7(383): 2.
217. Kahilo K, Kamal T, Elsayed N, Shukry M, Dishesh D, Hussein M. Fatty acid composition and acute toxicity study on *Moringa peregrina* fixed oil in Albino Rats. *Int J Pharma Sci.* 2015; 5(5): 1282-1288.
218. El-Hak HN, Moustafa AR, Mansour SR. Toxic effect of *Moringa peregrina* seeds on histological and biochemical analyses of adult male Albino rats. *Toxicol Rep.* 2018; 5: 38-45.
219. Balakrishnan BK, Krishnasamy K. Toxicity study of the ethanolic extract of *Moringa concanensis* Nimmo leaves in wistar rats. *Int J Pharma Bio Sci.* 2018; 9: 57-62.
220. Kerharo PJ. Un remède populaire Sengalais: Le 'Nebreday'(*Moringa oleifera* lann.) emploie thérapeutiques en milieu Africain chimie et pharmacologie. *Plantes Med Phytother.* 1969; 3: 14-219.