PHYTOCHEMICAL COMPOSITION OF *MORINGA OLEIFERA* ITS NUTRITIONAL AND PHARMACOLOGICAL IMPORTANCE

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Summary: Moringa oleifera is regarded as a multipurpose plant. It is an excellent source of nutrients, natural energy booster and a nature's medicine cabinet. This plant contains numerous important compounds e.g., glucose, rhamnose, glucosinolates, isothiocyanates, methionine, cysteine, tryptophan, phenylalanine, lysine, histidine, isoleucine, leucine, valine, alanine, threonine, glycine, glutamic acid and aspartic acid. It is used a food in many countries because it is rich in important nutrients including vitamins (A, B and K), minerals (K, Ca, Zn, Fe, P). It is leaves are comparable to milk and eggs in protein contents. The plant is an affordable source of vital nutrients and can be used to treat malnutrition. *M. oleifera* shows antimicrobial, hepatoprotective, cholesterol lowering, antidiabetic, antispasmodic, antiulcer, antitumor, antihypertensive, anti-inflammatory, antioxidant, antipyretic and diuretic potential. The plant is highly beneficial to treat depression, malnutrition, general weakness, osteoporosis, pregnancy, diabetes, lactation, semen deficiency, scurvy, psoriasis, hysteria, abnormal blood pressure, fever, eye and ear infections, cough, conjunctivitis, glandular issues, blood impurities, catarrh, bronchitis, anxiety, blackheads, skin infections, anemia, hysteria, pimples, shortness of breath, scouring, dementia, sore throat, sprains and tuberculosis. The plant is also used to cure neurological disorders, musculoskeletal disorders, cancer, cholera, chest congestions, asthma, headache, swellings, cough, diarrhea, blood pressure abnormality, pains in joints,

pimps, respiratory disorder, pimple, seizures, intestinal worms, breastfeeding, diabetes and hypertension. *M. oleifera* an an excellent source of antioxidants especially the leaves are a wealthy supply of antioxidant compounds.

Keywords: Moringa oleifera, phytochemicals, nutrients; malnutrition, diseases, multipurpose

INTRODUCTION

Plants serve as sources of food and form the basis of obtaining numerous unlimited medicinal and nutritional products. The plants like rice, cereals, wheat or corn are the main sources of human food and they fulfill nearly 60% food requirements of the world [24]. *Moringa oleifera* is a nutritious vegetable tree, which finds a broad range of uses and has its origin from the Northern part of the India. This plant is commonly familiar as *Moringa*, Drumstick and Horseradish (in English), as *Moringa oleifera* (in Latin), Sahjan (in Hindi), Surajana (in Punjabi), Swejan or Sajiwan (in Nepali), Sojne danta (Bengali) and Surajana (in Sanskrit). *Moringa* is not only important for human and animals but it also finds numerous industrial applications. The leaves contain high protein content (27%). In the 1980s, *Moringa oleifera* was grown as a herb for treating HIV in Uganda. In Pakistan, India, Afghanistan and Bangladesh it used in folk medicine. *Drumstick* is referred as a "miracle tree" or "wonder tree" [23]. It is a well-known multi-purpose tree having nutritious pod and poisonous free flowers and leaves. It finds applications as a good source of food, animal feed, cosmetic oils, medicines and water coagulants [49]. The oil (yield = 30-40% w/w) of *Moringa* seed is commercially called "Ben" or "Behen" oil due to the presence of high content of behenic acid. This oil meets with most of the required conditions of biodiesel standards of Europe, United States of America and Germany. So MO has been recognized an industrial crop for sustainable biodiesel production in many countries [57]. The roots, leaves, seeds, stem-bark, root-bark and pods have therapeutic properties. The close flowers are used as a vegetable in food and making tea which gives sufficient quantity of the potassium in addition to calcium [25]. *Drumstick is* erratically label as a "Miracle Tree", which means God's Gift to Man, "Tree of Life", Savior of poor, Mother's Best Friend. In several areas of Africa, it is usually used for the self-medication by the patient which are affected by hypertension, diabetes and HIV/AIDS [34].

Plants have been widely studied owing to their nutritional and medicinal value [42, 43, 44, 45]. There are recently greater investigations on *M. oleifera* since its every part possesses beneficial properties [36]. Current studies carried out to review the phytochemical composition, nutritional value and pharmacological importance of *Moringa oleifera*.

PHYTOCHEMICAL COMPOSITION

Drumstick tree is rich in the compounds especially common sugar, rhamnose, glucosinolate, isocytosinate *etc*. Its stem bark is comprised of two alkaloids namely moringinine and moringine [3]. The leaves are comprised of zinc (Zn), sodium (Na), iron (Fe), calcium (Ca), potassium (K), copper (Cu), manganese (Mn) and magnesium (Mg) [48]. Phytochemicals analysis of the leaves have shown the existence of tannins, anthocyanin, cardiac glycoside, carotenoid, terpenoids, saponins, steroids, alkaloids, flavonoid and anthraquinone in ethanolic as well as aqueous extracts. However, the ethanolic extract is comprised of lower amounts of phytochemicals than the aqueous extract as shown by quantitative analysis. The aqueous extract was found to contain higher amounts of alkaloids (3.07 ± 0.00), anthraquinone (11.68 ± 0.04), carotenoids (1.16 ± 0.05), steroids (3.21 ± 0.00), cardiac glycoside (0.36 ± 0.03), terpenoids (4.84 ± 0.05) and tannins (9.36 ± 0.04) while the ethanolic extracts possessed excessive saponins (1.46 ± 0.03) in addition to flavonoid (3.56 ± 0.03) all in g/100g [47]. *The stem and leaves tissues of M. oleifera* were found to contain a total of 32 metabolites out of which 22 metabolites were present in both the stem and leave tissues. The glutamine, tryptophan and glutamate were present only in stem tissues while *p*-cresol, tyrosine, guanosine, adenosine and 4-aminobutyrate were found only in leaf tissues [31]. The purified whole-gum exudate of M. *oleifera* shows the presence of D-glucose (9.37), D-xylose (2.93), L-rhamnose (6.15), L-arabinose (43.50), D-mannose (3.0) and D-galactose (34.00%) whereas the degraded gum was found to contain L-glucose (23.2), L-mannose (6-O) and L-galactose (70.4%) [5].

Moringa leaves demonstrate an energy value of 1440 Kcal/100g and contain an appreciable amount of crbohydrates (63.11%), crude proteins (17.01%), ash (7.93%), fatty acid (1.69%), crude fat (2.11%) and crude fibre (7.09%). The leaves also contain essential minerals including copper (6.10ppm), manganese (81.65ppm), phosphorous (30.15ppm), zinc (60.06 ppm), iron (107.48 ppm), sodium (192.95 ppm), potassium (0.97%), magnesium (0.38%) and calcium (1.91%) [48].

The ethanolic extracts of leaves, seeds and flowers, of *M. oleifera* were investigated. The flowers have shown the presence of Dodecanal, Decanoic acid, Sipo, Ocenol, Satol, Oleol, *cis*-9–Octadecen-1–ol and 9-Octadecen-1-ol. Seeds contain majorly the 9-Octadecenoic acid, Veridiflorol and Roridin E. The leaves were comprised of 15 components especially Safflower oil, Hi-oleic safflower oil, 2,6-Dimethyl-1,7-octadiene-3-ol, 4-Hexadecen-6-yne, 2-hexanone, 3-cyclohexyliden-4-ethyl-E2-dodecenylacetate, hexadecanoic acid, palmitic acid ethyl ester and ethyl palmitate [46]. In another studies, the leaves have also been reported to contain alanine, aspartic acids, valine, glycine glutamic acids, threonines, leucines, methionines, cysteines, tryptophans, phenylalanines, lysines, histidine, isoleucines while the flowers have shown the presence of Kaempferol-3-rutinoside 34 while

β-sitosterone, β-sitosterol, octacosonoic acid, vanillin and 4-hydroxy mellein were investigated in the steam [55]. There are also reports that seeds have several amino acids, 4-(α-L-rhamnosyloxy)benzyl isothiocyanate and moringyne [20]. Benzyl isothiocyanate was reported in the *Moringa* roots. The antimicrobil activity of plant against bacteria (both gram positive and gram negative) is owed to the presence of pterygospermin and spirochin components of the plant. **Figure 1** displays the structures of some phytoconstituents isolated from *M. oleiferea* [36].

The acid hydrolysis of the *Moringa* gum gives aldotriouronic acid and is characterized as O-(β-D-glucopyranosyluronic acid) (1→6)-β-D-galactopyranosyl,(1→6)-D-galactose [55].

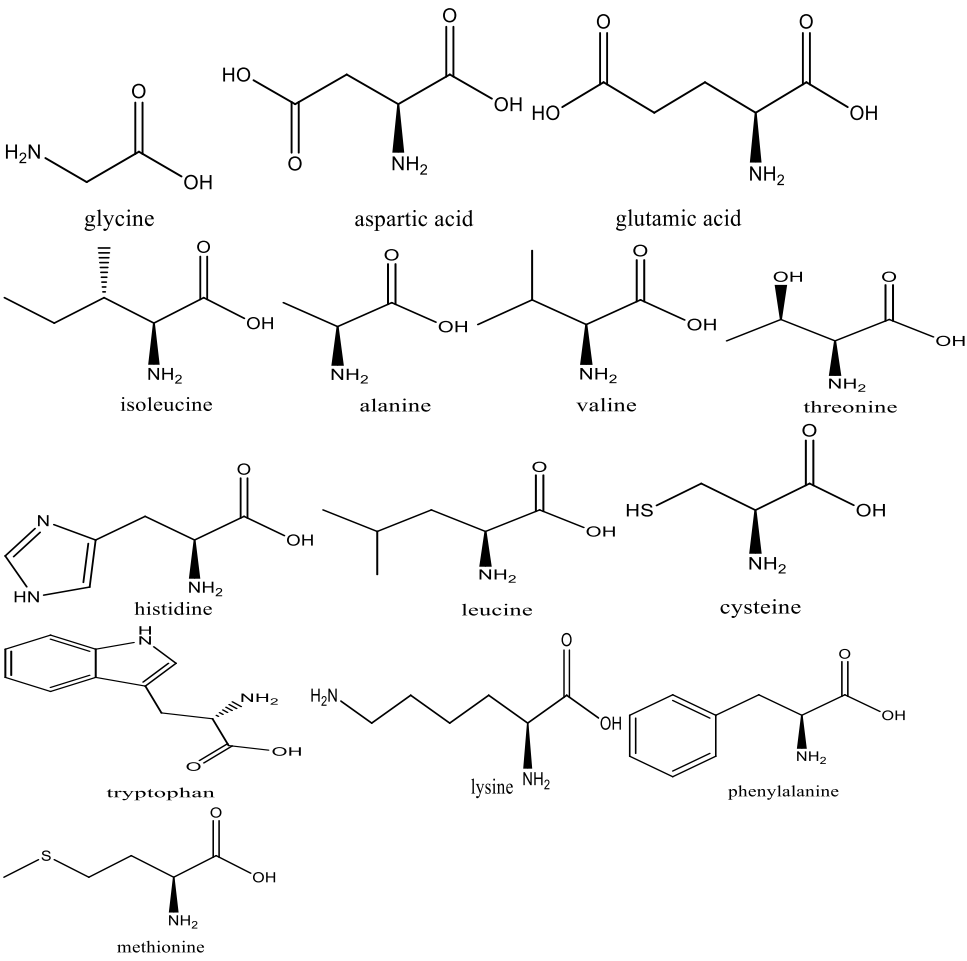

FIGURE 1. Structures of some phytoconstituents isolated from *M. oleiferea* [36]

NUTRITIONAL IMPORTANCE

M. oleifera is familiar as a natural energy booster and an excellent source of nutrition [22]. It is rich in nutritional ingredients like calcium, phosphorus, iron, vitamins (A,B and C), potassium, carotene and acts as an excellent source of natural antioxidants such as flavonoids, ascorbic acids, phenolics as well as carotenoids [2, 53]. *Moringa* leaves contain more quantity of the calcium, iron, vitamin A, potassium and vitamin C as compared to that of milk, spinach, carrots, bananas and oranges, respectively. The protein content in leaves is comparable to that present in milk and eggs [12]. Vitamin A provides defense against eye and skin diseases, ailments of heart, ailments of gastro-intestine and extra problems related to health; vitamin C enhances immunity against flu and cold; calcium gives strength to bone and teeth and prevents from osteoporosis; vitamin K is necessary for the proper functioning of proteins and brain [30; 41]. *M. oleifera* contains the highest amounts of vitamin C, vitamin E, iron and β-carotene when compared with other 3 species (*stenopetala, peregrine and drouhardii*) of *Moringa* while its protein content was second highest (highest was that of *stenopetala*) among the said species [15]. Each part of *Moringa oleifera* is safe to eat [25] as a food especially its tuberous roots, which show higher resistance to the arid and drought conditions. The immature flowers, pods or leaves of *Moringa* tree are useful for the cooking purposes in various parts of the world [32]. The plant is an affordable source of vital nutrients as well as nutraceuticals and can be used to eliminate malnutrition and hunger [57].

Asian people use flower, pods and young leaves of *M. oleifera* as a vegetable in their diet. Each part of this plant is re-newable source of phenolic compounds, γ-tocopherols, protein, vitamin C, β-carotene, sulfur containing amino acids, cysteine and methionine [14]. The fruit, immature pods, flowers and leaves of *M. Oleifera* serve as an excellent nutrititional vegetable in many countries including Pakistan, Africa, Hawaii, India and Philippines [40]. Vitamins "A" is present in fresh leaves of this plant and plays important role in the numerous physiological actions such as the, visions, reproduction, growth of embryo, developments, competences of immune system, cell explosion, cell differentiations and apoptosis [28]. The leaves of *M. Oleifera* are edible and excellent sources of nutrition for the all aged people. They are used to make salads and soups and also cooked and eaten like spinach. They contain essential, disease preventing nutrients and are rich source of vitamins (A, B, C), minerals (especially iron) and sulphur-containing amino acids cystine and methionine. The leaves consist of a well-balanced quantity of the amino acids (building blocks of proteins) which is unusual for a plant source [37].

The leaves serve as an excellent boon to people who are unable to obtain protein from meat or other sources. The presence of histidine and argentine components makes *M. Oleifera* a fantastic source of proteins for infants who could not make enough proteins according to the requirement of their growth [33].

The dried leaves of *M. Oleifera* contain even higher percentage of micro--nutrients including vitamin A (10 ten times than carrots), calcium (17 times than milk), potassium (15 times as than bananas), iron (25 times than spinach) and proteins (9 times than yogurt) [29, 33]. It is better to dry the leaves in shade (which retains 50-70% vitamin A) as compared to direct sunlight which retains 20-40% vitamin A). Moreover, the proteins of leaves may be broken down under the influence of high temperature [54]. The clean dried powder of *Moringa* leaves can reabsorb humidity during or after grinding so it should be placed at 50 °C for 30 minutes in order to lower its moisture content. The powder can be stored upto 6 months below 24°C in air-tight containers in the absence of light and humidity. Moringa is effective to combat malnutrition, particularly in nursing women and infants. For children aged 1-3, one rounded tablespoon (8 g of powder) is sufficient to satisfy nearly all the vitamin A needs, 23% of the iron, 40% of the calcium and 14% of the protein. A woman's daily calcium and iron requirements during breast-feeding or pregnancy are can be fulfilled by 6 rounded spoonful of leaf powder. Moringa was recommended as a natural nutrition for the tropics especially by 3 NGOs (non-governmental organizations) namely Educational Concerns for Hunger Organization, Church World Service and Trees for Life. This plant is full of leaves even at the end of a dry season when there is scarcity of other foods. The leaves of *M. Oleifera* can be eaten fresh or cooked. Moreover, they can be stored as dried powder without refrigeration for many months while their nutritional value is not lost. They also find applications in food fortification [16, 37]. The spoonful addition of the powder into the vegetables, soups and baby food can add the nutritional value without changing the taste. The powder also finds usage in place of fresh leaves to produce lead sauces, or its few spoonful can be added to other sauces just before serving. The taste of the sauce is not significantly changed by adding a small amount of this powder. Hence, there is always availability of Moringa leaves for good nutritional intake on regular basis [16]. The plant has very low demand of water and soil nutrients for its growth so it can easily be grown. The leaves have great commercial potential as they can be incorporated in common food diet to alleviate the deficiency of micronutrients and to prevent from chronic degenerative disorders. Thus the leaves may not only be an excellent source of income generation, employment and exports but they may also be used to treat malnutrition in poor countries, as good alternatives to imported food supplies [37]. There were investigations that the leaves of *M. oleifera* (from Lafia, Nigeria) can act as good good supplements for better health and growth performance of poultry [48].

Oxalate and oligosaccharides were investigated as the anti-nutrient factors in the leaves of *Moringa*. Raffinose and stachyose were not present in mature leaves, but present in seeds (22−98 mg/g dry weight) and in the young leaves (0− 14 mg/g dry weight) [65]. In the developing nations, drumstick plant used as a food, alter-

native to the imported foods supplements for treatment of malnutrition, especially between nursing mothers as well as infants by the virtue of the chemical constituents [1]. The excessive used part in this tree is leaves mainly that were use for the human's diet and animal's diet and use in the conventional medicine, which used for treatment of animals. Leaves have high content of proteins, iron, calcium, potassium, β-carotene, vitamins (relatively C and E), and in bioactive addition to antioxidant compound for example glucosinolates, phenolic acids, flavonoid and isothiocyanates, saponins and tannins. The special features of this plant make it suitable for fighting against the malnutrition and it is used as medicinal plant in the developing countries and underdeveloped countries [27]. **Table 1** displays the nutrient contents of mature *Moringa* leaves.

TABLE 1. Nutrient contents of mature *Moringa* leaves (100 g fresh weight) [65]

Species	DM-Protein		Ascorbate	Iron	Carotene	Calcium	Tocopherols
	(g)		(mg)				
Stenopetala	24	5.8	400	5.4	13	711	18
Oleifera	24	5.7	249	9.2	15	638	25
Peregrine	21	2.9	264	5.6	5	458	28
Drouhardii	29	5.0	388	8.7	11	745	14

PHARMACOLOGICAL VALUE

M. oleifera is a nature's medicine cabinet [22]. Its roots, leaves, bark, flowers, fruit of immature pods and seeds possess a number of therapeutic properties such as antimicrobial, hepatoprotective, cholesterol lowering, antidiabetic, antispasmodic, antiulcer, antitumor, antihypertensive, anti-inflammatory, antioxidant, antipyretic and diuretic potential. Moringa is highly beneficial in osteoporosis, general weakness, malnutrition and depression [2]. *Moringa* was widely used in traditional medicines for the treatment of hysteria, pimples, shortness of breath, scouring, dementia, sore throat, sprains, tuberculosis [13], pregnancy, diabetes, lactation, semen deficiency, scurvy, psoriasis, hysteria, abnormal blood pressure, fever, eye and ear infections, cough, conjunctivitis, glandular issues, blood impurities, catarrh, bronchitis, anxiety, blackheads, skin infections and for anemia. There are reports of uses of *Moringa* in ancient cultures due to its healing properties. Oil of *Moringa* finds an important value in cosmetics and use as a moisturizer (for hairs and body) and skin conditioner. It has been used in skin preparations and various ointments since Egyptian times [16, 38, 58].

M. oleifera is also used to cure neurological disorders, musculoskeletal disorders, cancer, cholera, chest congestions, asthma, headache, swellings, cough, diarrhea, blood pressure abnormality, pains in joints, pimps, respiratory disorder, pimple, seizures, intestinal worms, breastfeeding, diabetes and hypertension [60]. Plant can synthesize flavonoids as a response to the microbial infection. Eating the flavonoids has shown protection against various chronic diseases related to-oxidative stress, cancer and cardiovascular diseases. Leaf of this plant is a best source of the flavonoids [62].

The medicinal value of *Moringa* owes to its antimicrobial, antioxidant, anti-inflammatory, antispasmodic and antitumor activities, which are described below:

ANTIMICROBIAL ACTIVITY

In vitro antimicrobial potential of leaves, seeds, bark and roots of *M. oleifera* was tested against the bacteria, dermatophytes, yeast and helminths by disc-diffusion method. Aqueous extracts of fresh leaf juice and seeds lowered the growth of the *Staphylococcus aureus* and *Pseudomonas aeruginosa*. However, no action were demonstrated against *Candida albicans* [7]. Antibacterial potential of plant extracts against *Vibrio cholera*, *Staphylococcus aureus* and *Bacillus subtilis* is also reported [63]. The existence of the 4-α-L-rhamnosyloxy benzyl isothiocyanates in root extract renders antimicrobial potential to the plant [11]. *M. Oleifera* is also comprised of antibacterial principles e.g., pterygospermin and spirochin which are active against gram negative as well as gram positive bacteria [9, 36]. Its roots and flowers are rich in pterygospermin (an antibiotic substance). The flowers demonstrate both antibacterial and antifungal activities [8]. Seeds of this plant express antibacterial potential due to the presence of benzyl isothiocyanate, moringine and pterygospermin [21]. The bark extract of *Moringa* shows significant antifungal activity [4]; the stem bark juice is active against bacteria e.g., *Staphylococcus aureus* [35]. The juice of M. *oleifera* fresh leaves is found to stop the development of microorganisms (*Staphylococcus aureus* and *Pseudomonas aeruginosa*) which are pathogenic to man [7].

ANTIOXIDANT ACTIVITY

Aqueous ethanolic (70 %) and methanolic (80 %) extracts of frozen dried leaves display the radical scavenging as well as antioxidant activities. Drumstick leaves are considered as a potential source of the natural antioxidants [22]. Antioxidants are of greater significance for the prevention of stress that may cau-

se number of degenerative diseases. Relatively M.*oleifera* has complex profile of flavonoids including malonylglucosides, rutinosides, glucosides, kaempferol and traces of acetylglucosides of isorhamnetin and quercetin which are good antioxidants [59]. Leaf and seed extracts demonstrate bio pesticide activity. Leaves of this plant are a wealthy supply of antioxidant compounds [28]. Due to the existence of numerous sorts of the antioxidants such as carotenoids, flavonoid, phenolics, ascorbic acid, drumstick is able to extend the protection period in foods containing fats [39]. Regulation of thyroid hormone is possible with aqueous leaf extracts, which involve the treatment of hyperthyroidism and demonstrate antioxidant effects [50, 51].

ANTISPASMODIC AND ANTITUMOR ACTIVITY

Pharmacologically studies of *Moringa* leaves initiated that extract of ethanol and its constituent shows antispasmodic activity probably through calcium channel blockages [10]. *Moringa* leaf juice shows stabilizing effects on the blood pressures. The nitriles, thiocarbamates and glycosides of this plant are responsible for lowering effect of the blood pressure. Its roots possess antispasmodic activity and leaves of *Moringa* are the potential source of the anti-tumor activity [26]. *Moringa* is an effective anticancer plant due to the presence of a number of bioactive compounds. The presence of bioactive compounds especially niazimicin and thiocarbamates in leaves renders powerful anticancer activity to M. *oleifera* [19]. The different constituents of this plant show spasmolytic activity which supports the conventional use of this plant in gastrointestinal motility disorders [18].

OTHER ACTIVITIES

Leaves of M. *oleifera* possess centrally opioid and peripherally non-opioid anti-inflammatory and anti-nociceptive constituents. These studies also confirm the traditional uses of drumstick for treatment of diseases related to inflammation and pain. Strong analgesic activity was shown by alcoholic extracts of M.*oleifera* which are equivalent to dose of aspirin (25 mg per kg of the body mass) [6]. Drumstick leaves extracts or aqueous leaf extract showed anti ulcerogenic and anti-ulcer activity respectively demonstrate that antiulcer components dispersed extensively throughout the plant. Roots also possess hepatoprotective activity [64]. Drumstick root extracts reduce carrageenan induced paw oedema to a comparable degree. There were reports regarding the isolation of 1,3 dibenzyl urea and aurantiamide acetate from the roots of *M. Oleifera*. 1,3 dibenzyl urea showed conside-

rable inhibition of IL-2 and significant analgesic activity while aurantiamide acetate exhibited significant inhibition of IL-2 and TNF-α. The results demonstrate the analgesic and anti-inflammatory/anti-arthritic potential of *M. Oleifera* roots. The ethyl acetate and aqueous leaves extract of dried leaf of drumstick possess significant wound healing potential [52]. The presence of blood pressures lowering constituents and decrease of lipid level has made this plant highly valuable for the treatment of circulatory system disorders. The crude extract of drumstick leaves have important cholesterol-lowering action in the serum of more fat diet [61]. Indian use leaves of this plant for herbal drugs as a hypocholesterolemic agent in the overweight patients [17].

The alcoholic and aqueous extracts of flowers or roots of M. oleifera were subjected to antihepatotoxic activity evaluations in paracetamol treated albino rats. Liver function was assessed based on bilirubin, alkaline phosphatase (SALP), serum levels of transaminase (SGPT, SGOT) and body weight ratio. All the extracts were found to exhibit antihepatotoxic potential [56].

CONCLUSIONS

Moringa oleifera from monogeneric group (*Moringa*ceae) of species is the most extensively cultivated plant. Component of the tree contains numerous important mineral, addition to it *moringa* is superior source of the vitamins, β-carotene, protein, phenolics along with various amino acids. M.*oleifera* is very helpful to overcome the malnutrition, mainly in nursing mothers as well as infants due to the existence of high amount of essential nutritional composition. *Moringa* leaf contains extra vitamin A vitamin C and calcium than that of carrots, oranges and milk, excess iron, and potassium than that of spinach and banana and proteins quantity of *Moringa* leaves is superior to eggs and milks.

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