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Lemna minor: Traditional Uses, Chemical Constituents and Pharmacological Effects- A Review

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Abstract: Lemna minor was used traditionally as antipruritic, antiscorbutic, astringent, depurative, diuretic, febrifuge and soporific. It was also used in the treatment of colds, measles, oedema and difficulty in urination. It contained carbohydrates, proteins, lipids, flavonoid, trace elements and many other contents. The pharmacological studies revealed that it possessed antimicrobial, antioxidant, cytotoxic and immunomodulatory effects. The current review discussed the traditional uses, chemical constituents and pharmacological effects of Lemna minor.

Keywords: traditional uses, constituents, pharmacological effects, *Lemna minor*

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I. INTRODUCTION

Recent reviews showed that plants produce many secondary metabolites which are bio-synthetically derived from primary metabolites and constitute an important source of many drugs. Recent reviews revealed that the medicinal plants possessed central nervous[1], cardio-vascular[2], antioxidant[3], reproductive[4-5], gastro-intestinal[6-7], respiratory[8], antidiabetic[9-10], antimicrobial[11-12], antiparasitic[13-14], dermatological [15-16], anticancer[17-18], anti-inflammatory, antipyretic and analgesic[19-20], immunological[21-22], hepato and reno-protective[23-25] and many other pharmacological effects. *Lemna minor* was used traditionally as antipruritic, antiscorbutic, astringent, depurative, diuretic, febrifuge and soporific. It was also used in the treatment of colds, measles, oedema and difficulty in urination. It contained carbohydrates, proteins, lipids, flavonoid, trace elements and many other contents. The pharmacological studies revealed that it possessed antimicrobial, antioxidant, cytotoxic and immunomodulatory effects. The current review was designed to highlight the traditional uses, chemical constituents and pharmacological effects of *Lemna minor*.

II. PLANT PROFILE

Synonyms:

Hydrophace minor, Lemna conjugate, Lemna cyclostasa, Lemna minima, Lemna minor var. minima, Lemna minor var. orbiculata, Lemna minor var. oxymitra, Lemna monorhiza, Lemna obcordata, Lemna ovate, Lemna palustris, Lemna rwandensis, Lenticula vulgaris, Lenticula cyclostasa, Lenticula minima, Lenticula minor, Lenticula palustris, Lenticula vulgaris, Lenticularia monorhiza, Lenticularia vulgaris[26].

Taxonomic classification:

Kingdom: Plantae, **Subkingdom**: Viridiplantae , **Infrakingdom**: Streptophyta, **Superdivision**: Embryophyta, **Division**: Tracheophyta, **Subdivision**: Spermatophytina, **Class**: Magnoliopsida, **Superorder**: Lilianae, **Order**: Alismatales, **Family**: Araceae, **Genus**: *Lemna*, **Species**: *Lemna minor*[27].

Common names:

Arabic: Adas Almay; **Chinese**: qing ping; **English**: common duckweed, duckweed; **French**: lenticule mineure; **German**: kleine Wasserlinse; **Spanish**: lentejas de agua; **Swedish**: andmat[28].

Distribution:

It was distributed in **Africa**: (Algeria, Egypt, Libya, Morocco, Tunisia, Ethiopia, Sudan, Kenya, Uganda, Rwanda, Zaire Mozambique and South Africa), **Asia**: (Yemen, Afghanistan, Iran, Iraq, Palestine, Jordan, Lebanon, Syria, Turkey, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, Russian Federation, China, India, Nepal and Pakistan), **Europe**: (Denmark, Finland, Ireland, Norway, Sweden, United Kingdom, Austria, Belgium, Czech, Germany, Hungary, Liechtenstein, Luxembourg, Poland, Slovakia, Switzerland, Belarus, Estonia, Latvia, Lithuania, Moldova, Russian Federation, Russian Federation-European part, Ukraine,

Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Italy, Montenegro, Romania, Serbia, Slovenia, France, Portugal and Spain), and in **Northern America**: (United States and Canada)[28].

III. DESCRIPTION

It is a floating aquatic plant consists of a single oval or oval-obovate thallus, it is about 2-5 mm long and 1.5-3.5 mm across. The thallus has a slightly succulent texture and smooth margins. The upper thallus surface is medium green and slightly convex along a faint longitudinal ridge, the lower thallus surface is light green and flat. Both surfaces are glabrous. A single rootlet up to 2 cm long develops near the center of the thallus' lower surface. This rootlet is slender and white with a tip that is usually obtuse. At the base of the rootlet, there is a short cylindrical sheath. On rare occasions, a single tiny flower is produced that spans about 1 mm across. This flower consists of a membranous cup-shaped scale, a single pistil, and 2 anthers. The flower is replaced by a single fruit (1 mm in length or a little less) that contains a single ribbed seed. However, this plant reproduces primarily by a budding process from two lateral reproductive pouches. The offsets of this budding process are identical genetically to the mother plant. An offset is connected to the mother plant by a slender white stipe, but this soon withers away. During the summer, Common Duckweed often forms dense colonies of plants from budding. During the cooler weather of fall, small starchy buds called (turions) are produced that sink to the bottom of the water body. This dormant state continues until the warmer weather of spring, when the turions rise to the water surface and the growth process begins again[29-30].

IV. TRADITIONAL USES

The whole plant was used as antipruritic, antiscorbutic, astringent, depurative, diuretic, febrifuge and soporific. It was also used in the treatment of colds, measles, oedema and difficulty in urination[31-32].

In addition, it was used in the treatment of vitiligo, podagra, and upper respiratory tract inflammation. Duckweed formulations were used in the treatment of rheumatism, liver diseases, and thyroid diseases. As external application, duckweed formulations were used in the treatment of abscesses, chronic wounds, and furuncles[33-35]. It was used internally, in combination with other medicinal herbs, to treat inflammation of the upper respiratory tract, and as a anti-inflammatory and blood purifying remedy for chronic rheumatic ailments such as rheumatoid arthritis and osteoarthritis. In China, the herb was used internally for body temperature regulation (reduce high fever) and swellings (edema). Externally it was applied as a remedy for various skin ailments, such as rash, eczema, measles, and insect bites[36].

Part used medicinally:

The whole plant was used in herbal medicine, either fresh or dried[33-36].

V. CHEMICAL CONSTITUENTS:

Nutritional analysis showed that *Lemna minor* contained (of dry weigh): crude protein 16-45%, fat 4.4-4.0%, *p*-coumaric acid 0.015%, fiber 8-10%, ash 4-5%, and carotenoid[37-42].

The total iodine content as iodide ions was 0.0294 ± 0.001%. The flavonoid content as luteolin-7-glucoside (cinnaroside) was 0.38 ± 0.01%. Atomic emission spectrographic studies showed that the common duckweed contained 14 elements: calcium 4990 mg/100 g, potassium, silicon 2495 mg/100g, sodium 1870 mg/100g, magnesium 155mg/100g, iron 934 mg/100g, phosphorus515 mg/100 g, aluminum 0.93 mg/100g, manganese 935 mg/100g, nickel 0.93 mg/100g, copper 0.78 mg/100 g, lead 0.03 mg / 100 g, molybdenum 0.02 mg/ 100 g and zinc 0.01 mg/100 g[43-44].

The duckweed was a rich source of essential (39.20%), non-essential (53.64%), and non-proteinogenic (7.13%) amino acids. Among essential amino acids, leucine, isoleucine, and valine constituted 48.67%. Glutamic acid was 25.87% of total non-essential amino acids. Citrulline, hydroxiproline, taurine, histidine, leucine, lysine, methionine, phenylalanine, threonine and tryptophan were recorded in the duckweed [45].

However, the protein of *Lemna minor* characterized by high content of albumins and relatively low globulins, the molecular weight of the protein fractions were estimated as above 176,000 and below 14,000. Amino acid contents in *Lemna minor* protein were aspartic acid 9.89, threonine 5.08, serine 4.05, proline 4.88, glutamic acid 13.53, glycine 7.36, alanine 7.88, cystine traces traces, valine 7.67, methionine 0.39, izoleucine 5.89, leucine 10.27, tyrosine 2.76, phenylalanine 6.28, lysine 6.20, histidine 2.32, arginine 4.67 and tryptophanl 0.85 % of the total protein[39, 41].

The fatty acid composition was dominated by PUFA, 60–63% of total fatty acids, largely α-linolenic acid 41 to 47% and linoleic acid 17–18%[45]. Total fatty acids content was 10.6 ± 0.8 % and total triacylglycerol was 0.03 ± 0.01% of dry weight. Three fatty acids palmitic, linoleic acid, and α-linolenic acid comprised more than 80% of total duckweed fatty acids[46]. However, Politaeva *et al.*, mentioned that lipid fraction from duckweed biomass consisted of unsaturated acids (76.7 mass %) predominantly oleinic and linoleic. The major saturated fatty acids (23.3%) were palmitinic and stearinic[47].

The lipophilic substances isolated from duckweed were: hexanal, trans-2-heptenal, caproic acid, ethycaproate, trans-2-octenal, ethylheptanoate, nonanal, 2,6-dimethylcyclohex anol, Menthol, pyrrol-2,5-dione, internal standard, tetradecane, pentadecane, dihydroactinidiolide, heptadecane, loliolide, ethyltetradecanoate, trans-neophytadiene, hexahydrofarnesylace tone, cis-neophytadiene, ethylpentadecanoate, ethylpalmitate, heneicosane, phytol, tricosane, pentacosane, heptacosane, campesterol, stigmasterol, ϒ-sitosterol, spinasterone and sitosterone[43].

The analysis of the composition and structure of duckweed cell walls revealed that it was composed of carbohydrates 51.2% (w/w) and starch 19.9% of dry matter. It was rich in cellulose and also contains 20.3% pectin (comprising galacturonan, xylogalacturonan, rhamnogalacturonan) and 3.5% hemicellulose (comprising xyloglucan and xylan), and 0.03% phenolics[37].

Four isoprenoids in addition to diterpenes were isolated from *Lemna minor* [48]. The total phenolics in the the lyophilized water extract was 22.0 ±0.8 µg/mg extract and the total flavonoids was 16.7 ±0.0 µg/mg extract, while, the total phenolics in the ethanol extract was 4.5 ±0.2 µg/mg extract and total flavonoids was 17.4 ± 0.1 µg/mg extract[49].

VI. PHARMACOLOGICAL EFFECTS

Antimicrobial effect:

The antibacterial effect of the methanol extract of the leaves of *Lemna minor* was studied against *Bacillus subtilis* (NCIM-2063), *Escherichi coli* (NCIM-2065), *Pseudomonas aeruginosa* (NCIM-2200), *Staphylococcus aureus* (NCIM-2079), *Micrococcus luteus* (NCIM-2103), *Shigella flexneri* (NCIM-2012), *Bacillus megaterium* (NCIM-2256) and *Salmonella typhi* (NCIM-2501). Methanolic extracts of *Lemna minor* leaves showed good antibacterial activity against *Shigella flexneri*, while it possessed moderate activity against *Bacillus subtilis, Pseudomonas aeruginosa* and *Micrococcus luteus*, whereas *Escherichi coli, Staphylococcus aureus* and *Salmonella typhi* showed weak response. The least MIC values for methanol extracts of *Lemna minor* leaves were (12, 40, 60, 90 and 170 µg/ml respectively) against *Shigella flexneri, Bacillus subtilis, Micrococcus luteus, Pseudomonas aeruginosa* and *Staphylococcus aureus*[50].

The antimicrobial activities of the lyophilized water extract and ethanol extract of duckweed were studied against *Staphylococcus epidermidis, Staphylococcus saprophyticus, Staphylococcus warneri, Citrobacter freundii, Citrobacter koseri, Neisseria lactamica, Neisseria sicca, Micrococcus luteus, Bacillus cereus, Bacillus subtilis,* and *Streptococcus pneumoniae,* and also studied for anticandidal effect against *Candida parapsilosis* and *Candida glabrata*. Most of the gram-positive and gram-negative bacterial and *Candida* species were inhibited by both extracts[49].

The antibacterial effect of the methanol extract of *Lemna minor* was studied against *Aeromonas hydrophila, Pseudomonas putida, Vibrio cholerae* Bengal, *Vibrio cholerae* El-Tor, *Vibrio cholerae* Non, *Vibrio alginolyticus, Staphylococcus aureus, Streptococcus agalactiae* (isolates from human and fish), *Citrobacter freundii* and *Escherichia coli. Vibrio cholera* and *S. agalactiae* (human). Among all 11 bacteria tested, were not susceptible to the duckweed methanolic extracts. Other bacterial isolates showed response to methanolic extracts, the inhibition of bacterial growth occurred at the concentration of 1.8 - 2.0 mg/ml for all the bacteria tested[51].

The antimicrobial activity of the extracts of *Lemna minor* was screened against *E. coli* and *Staphylococcus aureus.* The extract of *Lemna minor* was active against *Staphylococcus aureus* with a mean inhibition zone of 25 mm[52].

The antimicrobial activity aqueous extract of whole *Lemna minor* was studied against four bacterial isolates (*Pseudomonas fluorescens, Salmonella typhi, E. coli* and *Bacillus subtilis*) and one fungal strain. *Lemna minor* showed maximum inhibition against Gram positive and Gram negative bacteria and fungi at higher concentration as compared to control[53].

Antioxidant effect:

The antioxidant and antiradical, of the lyophilized water extract and ethanol extract of duckweed were studied using different *in vitro* models. At the 45 µg/ ml concentrations, the lyophilized water extract and ethanol extract, showed 100% and 94.2% inhibition, respectively, on lipid peroxidation of linoleic acid emulsion. On the other hand, BHA, BHT, α-tocopherol, and trolox demonstrated inhibition of 92.2%, 99.6%, 84.6%, and 95.6%, respectively, on peroxidation of linoleic acid emulsion at the same concentration. H_2O_2 scavenging activity, Ferrous ion chelating activity and Superoxide scavenging activity for water and ethanol extract were 92.3 ± 2.8 and 85.7 ± 1.1, 63.0 ± 6.9 and 61.0 ± 6.0, and 38.8 ± 3.1 and 23.0 ± 2.4%, respectively [49].

Cytotoxic effect:

Brine shrimp lethality assay (BSLA) was used to determine the toxicity of the methanol extract of *Lemna minor*. The methanolic extracts of duckweed showed cytotoxic activity towards brine shrimp. The lethal concentrations of plant extract resulting in 50% mortality of the brine shrimp was 140.64 µg/ml[(51)].

Immunomodulatory effect:

The effect of apiogalacturonanic pectin of *Lemna minor* (1–2 mg per mouse) was studied on the inflammatory response to ovalbumin injected intradermally into the footpad of control and ovalbumin-fed mice. Oral administration of ovalbumin was shown to result in sensitization that increased inflammation. Ovalbumin admixed with apiogalacturonanic pectin of *Lemna minor* was found to increase by two-fold footpad edema in comparison with the mice receiving ovalbumin alone[(54)].

The effect of variable doses of flavonoids (1-30 mg/ml; 50 µl) extracted from whole plant of *Lemna minor* (duckweed), on virally infected human whole blood against ovalbumin (OVA). The results showed that the flavonoids at higher doses showed immunosuppressive effect, they declined the proliferation, free haemoglobin content in the blood plasma and antibody production[(55)].

The immunomodulatory activity of aqueous extract of whole *Lemna minor* was studied against ovalbumin which used as coating antigen for estimating antibody production against variable doses of aqueous extract of *Lemna minor* pertaining to determined its immunological activity. Aqueous extract at high doses showed enhancement in antibody titer against ovalbumin[(53)].

Dose:

As a decoction: The usual daily dose is 3.10 g herb for internal use, as a powder: 1-2 g daily for internal use. External uses: as much as needed[(36)].

Side effects and toxicity:

Duckweed was considered a safe herb and no serious side effect have been reported when it was used in therapeutic doses. If duckweed was used for human consumption, it should be noted that the herb contained relatively high amounts of calcium oxalate, a substance that can contribute to the formation of kidney stones. Duckweed can also accumulate toxins from the water, so it should not be collected from a highly contaminated water[(36)].

VII. CONCLUSION

This review discusses the traditional uses, chemical constituent, pharmacological and therapeutic effects of *Lemna minor* as promising herbal drug because of its safety and effectiveness.

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