

Review article

Aquatic plants of the Far East of Russia: a review on their use in medicine, pharmacological activity

Ya VB

Abstract: The review provides information on the medicine application of 30 aquatic plant taxa growing in the Russian Far East, and the prospects for their practical use. A list of aquatic plants on the pharmacotherapeutic action is done. The greatest number of species of aquatic plants has analgesic, antipyretic, anti-inflammatory, stomach and antidiarrheal, wound-healing properties. It is revealed that the most widely in traditional medicine in Asia and Europe are used *Nelumbo nucifera*, *Trapa natans*, representatives of the family Lemnaceae, Nymphaeaceae, genus *Potamogeton*.

Key words: aquatic plants; traditional medicine; wound healing; analgesic; Far East of Russia

DOI: <http://dx.doi.org/10.3329/bjms.v14i1.21554>

Bangladesh Journal of Medical Science Vol. 14 No. 01 January'15. Page: 9-13

Introduction:

Aquatic plants are widely used in medicine of the peoples of Europe and Asia. Medicinal properties of plants are determined by the presence of chemical substances with physiological effects on humans and animals in their bodies¹.

Medicinal plants: from history

The most widely used in traditional medicine of Asia is *Nelumbo nucifera* Gaertn. (*N. komarovii* Grossh.), it is evidenced by the large number of publications²⁻¹². There is a detailed description of the lotus and its medicinal properties in ancient Chinese books and treatises. Chinese Pharmacopoeia indicates that Lotus is one of the major drugs in medicines¹³. The rhizomes are used as sedative, nutritional agent, with nervous exhaustions, metabolic disorders, liver diseases, avitaminosis B¹. Rhizome decoction is used as an antipyretic in pneumonia and bronchial asthma. The seeds are used as an antiemetic. Leaves and nuts are prescribed for avitaminosis and as a diuretic, anti-inflammation agent; have styptic, anthelmintic and demulcent actions, in particular with hemorrhoids. It is recommended as an anticeptic for gonorrhoea, liver, kidney, spleen diseases; as an antidote with bites of snakes and scorpions. Contained in embryos, shoots and young leaves alkaloid nufarin restores and stimulates respiration after its stopping. In Japan, in conjunction with other plants it is used for the treatment of cervical cancer. In India, Korea, Thailand, Egypt leaf extract is used in treating tumors of different etiology^{12,14-23}.

All species of family Nymphaeaceae have pronounced pharmacological properties. Essence of fresh rhizomes of *Nuphar pumila* (Timm) DC. has a stimulating effect on the function of the sex glands and women use in prolapse of the uterus. Furthermore, extracts of leaves and flowers are used for stomach cramps, enuresis, cough, back pain, kidney disease, nervous exhaustion, metabolic disorders. The plant is toxic and should be used with caution, fearing overdose^{10,16}. All parts of *Nymphaea tetragona* Georgi are used in folk medicine of Siberia and China. In diseases of the bladder and kidneys it is used infusions and decoctions of leaves and petioles; infusions of flowers have antipyretic effect, rhizomes help with bronchial asthma and lung disease^{10,24}.

Representatives of the family Lemnaceae are widely used in folk medicine in Russia, China and some European countries. Herb powders of *Lemna minor* L., *L. trisulca* L., *Spirodela polyrhiza* (L.) Schleid. have antipyretic, diuretic, analgesic, emollient, styptic, tonic, cooling, choleric, antiscorbutic, anthelmintic, anti-inflammation, antimicrobial actions. Those are an important source of micronutrients, polysaccharides and essential proteinogenic amino acids^{4,5,10,24-30}. In Chinese and Russian folk medicine, tincture of *Lemna minor* is used in hives, vitiligo, asthma, influenza, and as a general tonic. In Eastern Siberia infusion of *Lemna minor* is recommended for diabetes. In some Western European countries it is used for asthma, polyps, rhinitis and other diseases of the nose and throat, inflammation

Corresponds to: Bolotova Ya V, Amur Branch of the Botanical Garden-Institute of FEB RAS. **Email:** yabolotova@mail.ru

and swelling of the mucous membrane of the respiratory tract. Compress made of leaves *Spirodela polyrhiza* is used for erysipelas and leprosy; infusion of herbs is for edema and gout, as a diaphoretic in pediatric practice³; together with *Lemna minor* it is used as a poultice for gout, rheumatism; for washing and rinsing it is used with scorbutic and syphilitic ulcers, eye diseases. Herb *Lemna trisulca* has choleric properties and phytoncidic activity^{4,24,25}.

In the literature there are reports on the use in traditional medicine of the species of the genera *Utricularia* L. and *Myriophyllum* L.³¹. The herb *Utricularia macrorhiza* Le Conte is considered diuretic; it is applied to wounds and burns as wound healing. *Myriophyllum spicatum* L. is used as an external agent for cleaning wounds festering.

In Indian medicine, the herb *Ceratophyllum demersum* L. is used in jaundice, for scorpion bites, as an antipyretic and antimalarial; in China it is used with hemoptysis; aqueous extract of the plant has antidiarrhoeal and wound healing effect^{5,32,33}.

In Chinese medicine leaves and shoots of *Brasenia schreberi* J.F. Gmel. are used as a tonic, astringent and gastric mucous remedy for respiratory diseases (tuberculosis). Extracted from leaves quercetin-7-O-?-D-glucopyranoside has antiinflammation activity³⁴. *Ottelia alismoides* (L.) Pers. is used for hemoptysis, asthma, difficulty urinating, externally for skin diseases, burns. According to Chinese scientists the plant is a promising drug raw material, having anti-tuberculosis effect³⁵. *Salvinia natans* (L.) All. finds its application in general exhaustion, fever, eczema, skin diseases, herb extract exhibits antimicrobial and antioxidant activity³⁶⁻³⁸.

In Europe the herb *Batrachium eradicatum* (Laest.) Fries is used in intermittent fever, asthma, aches and pains, rheumatic pains, as a distracting mean in pain of joints and headaches; it is considered as a mean of stimulating sexual function, but its reception often causes poisoning¹⁰. In Tibetan medicine with ascites there are in use aerial parts of *Thacla natans* (Pall. ex Georgi) Deyl et Soják, for stomach and headaches – *Batrachium trichophyllum* (Chaix) Bosch^{4,39}.

The stems and leaves of *Nymphoides peltata* (S.G. Gmel.) O. Kuntze are used in the treatment of rheumatism, sciatica, headaches, in Chinese medicine it is used in disturbance of sweating, fever,

measles, hives, difficulty urinating, swelling, snakebites^{10,15}.

Raw stuff of *Monochoria korsakowii* Regel et Maack exhibits an inhibitory effect against the pathogen dysentery²⁵.

In China *Hippuris vulgaris* L. is used as an anti-inflammatory agent in diseases of the stomach and small intestine, respiratory, liver¹⁰.

Infusion of *Callitriche palustris* L. is used for washing sore eyes, as a diuretic in dropsy and diseases of the urinary organs; in Tibetan medicine it is used for the treatment of burns^{4,40}.

In Chinese medicine is used tubers, leaves and seeds of the genus *Sagittaria* L. Leaf juice of *Sagittaria natans* Pall. and *S. trifolia* L. is used as a shrink mean to accelerate liberation of postpartum discharge. Thanks to the antiseptic properties, the herb is used in the treatment of skin diseases, in Tibetan medicine it is used to treat wounds, and the scar tissue doesn't form. Tubers of these plants contain salts of phosphoric acid and substances that strengthen the nervous system^{4,10,25,41}.

In different countries the popular use has *Persicaria amphibia* (L.) S.F. Gray., in Transbaikalia it is used to treat gout and diabetes, in Altai for hemorrhoids, in Tajikistan for bone fractures; in folk medicine in Austria it is used to treat nasal polyps and cancers, in Indian medicine – it founds the use in syphilis, opium poisoning (as an antidote), in Chinese for dysentery, skin diseases^{4,10,39}.

Species of the genus *Trapa* L. has long been used in folk medicine in Russia, India, China as an anti-inflammatory, astringent, cholagogue, tonic, stomachic, diuretic, anti-toxic agents^{42,43} it is revealed significant antioxidant properties compare to other natural and synthetic antioxidants⁴⁴⁻⁴⁶. In its leaves pharmacologists found valuable medicinal substance – neorutin. Contained in the kernel of the seed *Trapa natans* L. s.l., indispensable fatty acids have anti-sclerotic action⁴⁷. The juice from the fruit of the ancient Greek physicians used in inflammation of the eyes and against abscesses in the mouth. Tea made of the shell *Trapa* in Cambodia is considered a tonic for fever, but in large doses causes impotence⁴⁸. The extract of the fruits has a high antibacterial activity against a number of pathogenic bacterial species^{49,50}. Circassians used plants *Trapa* as a remedy for the treatment of obesity and the weak-

ness of the nerves⁵¹. Modern research of Japanese scientists has identified properties of polyphenols from fruits *Trapa japonica* Fler. significantly to reduce the blood glucose level⁵².

Recently it is discovered high antimicrobial activity of lipids of the genus *Potamogeton* L., which completely inhibited the growth of most test cultures of microorganisms, including pathogens of the most common and dangerous diseases⁵³. In folk medicine of China *P. natans* L. is used in the treatment of inflammation in the lining of the eye, as anthelmintic, used together with *P. perfoliatus* L. is a treatment in diseases of the skin¹⁰. In Japanese medicine broth of *P. distinctus* A. Benn. is used with meat, fish and alcohol food poisoning, dried herb, mixed with sugar and soy flour is applied to burns. Infusion of the leaves of *P. natans* in Arabic medicine is used for stomach cramps, diarrhea (similar to *P. pusillus* L., *P. crispus* L.) and as antiscorbutic and wound healing. In Tibetan medicine *P. berchtoldii* Fieb., *P. pusillus* used in the treatment of arthritis^{4,25}.

Conclusion and recommendations:

Thus, the analysis of literature data allowed us to establish a wide range of pharmacological action of aquatic plants. The species *Nelumbo nucifera*, *Trapa natans* of the genus *Potamogeton*, families Lemnaceae, Nymphaeaceae have the greatest effect of pharmacotherapeutic action. Many of them have retained their importance to the present.

For usability of using information there is a list below of aquatic plants on the pharmacotherapeutic action:

Antioxidant agents – *Salvinia natans*, *Trapa natans*, *Nelumbo nucifera*.

Antitoxic agents – *Ceratophyllum demersum*, *Nelumbo nucifera*, *Nymphoides peltata*, *Potamogeton distinctus*, *Persicaria amphibia*, *Trapa natans*.

Bactericidal and antiseptic agents – *Nelumbo nucifera*, *Sagittaria natans*, *Sagittaria trifolia*, *Trapa natans*.

Analgesic, antipyretic and anti-inflammatory drugs – *Batrachium eradicatum*, *Batrachium trichophyllum*, *Ceratophyllum demersum*, *Hippuris vulgaris*, *Lemna minor*, *Lemna trisulca*, *Nelumbo nucifera*, *Nuphar pumila*, *Nymphaea tetragona*, *Persicaria amphibia*, *Nymphoides peltata*, *Potamogeton berchtoldii*, *Potamogeton pusillus*, *Sagittaria natans*, *Sagittaria trifolia*, *Salvinia natans*, *Spirodela*

polyrhiza, *Trapa natans*.

Astringents – *Brasenia schreberi*, *Trapa natans*.

Hepatoprotective agent – *Ceratophyllum demersum*, *Nelumbo nucifera*.

Antiallergic agents – *Lemna minor*, *Nymphoides peltata*.

Gastric and antidiarrheals – *Batrachium trichophyllum*, *Brasenia schreberi*, *Ceratophyllum demersum*, *Hippuris vulgaris*, *Monochoria korsakowii*, *Persicaria amphibia*, *Potamogeton natans*, *Potamogeton crispus*, *Potamogeton pusillus*, *Trapa natans*.

Cholagogue – *Lemna minor*, *Lemna trisulca*, *Spirodela polyrhiza*, *Trapa natans*.

Hemostatic agents – *Lemna minor*, *Lemna trisulca*, *Nelumbo nucifera*, *Spirodela polyrhiza*.

Exterior agents – *Brasenia schreberi*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Nelumbo nucifera*, *Spirodela polyrhiza*.

Anthelmintic agents – *Lemna minor*, *Lemna trisulca*, *Nelumbo nucifera*, *Potamogeton natans*, *Spirodela polyrhiza*.

Antiemetics – *Nelumbo nucifera*.

Healing agents – *Callitriche palustris*, *Ceratophyllum demersum*, *Lemna minor*, *Persicaria amphibia*, *Potamogeton distinctus*, *Potamogeton natans*, *Potamogeton perfoliatus*, *Utricularia macrorhiza*, *Sagittaria natans*, *Sagittaria trifolia*, *Salvinia natans*.

Medications for the uterus – *Nelumbo nucifera*, *Nuphar pumila*, *Sagittaria natans*, *Sagittaria trifolia*.

Sedatives – *Nelumbo nucifera*.

Antispasmodic agents – *Nuphar pumila*.

Treatments for avitaminosis – *Nelumbo nucifera*, *Lemna minor*, *Lemna trisulca*, *Potamogeton natans*, *Spirodela polyrhiza*.

Use in diseases of the eye diseases – *Callitriche palustris*, *Lemna minor*, *Potamogeton natans*, *Spirodela polyrhiza*, *Trapa natans*.

Use in of the respiratory diseases – *Batrachium eradicatum*, *Brasenia schreberi*, *Ceratophyllum demersum*, *Hippuris vulgaris*, *Lemna minor*, *Ottelia alismoides*, *Nelumbo nucifera*, *Nymphaea tetragona*.

Use in diseases of the genitourinary system – *Batrachium eradicatum*, *Brasenia schreberi*, *Callitriche palustris*, *Lemna minor*, *Lemna trisulca*, *Nelumbo nucifera*, *Nuphar pumila*, *Nymphaea tetragona*, *Nymphoides peltata*, *Persicaria amphibia*, *Spirodela polyrhiza*.

Use for diseases of the central nervous system – *Trapa natans*.

Use in the treatment of tumors – *Nelumbo nucifera*, *Persicaria amphibia*.

Use for metabolic disorders – *Lemna minor*, *Nelumbo nucifera*, *Nuphar pumila*, *Persicaria amphibia*, *Spirodela polyrhiza*, *Trapa natans*.

Use for the prevention and treatment of atherosclerosis – *Trapa natans*.

Stimulants – *Nelumbo nucifera*.

Tonic and fortifying agents – *Brasenia schreberi*, *Lemna minor*, *Lemna trisulca*, *Nelumbo nucifera*, *Nuphar pumila*, *Sagittaria natans*, *Sagittaria trifolia*, *Salvinia natans*, *Spirodela polyrhiza*, *Trapa natans*.

Diaphoretics – *Spirodela polyrhiza*.

References:

- Karev FI (comp.). Plants used in everyday life (fruit, berries, medicinal and ornamental). Moscow: Moscow University Press, 1966. Palibin IV. A few words about the lotus (*Nelumbo nucifera* Gaertn.) and its economic importance. *Math Empire SPb Bot Garden* 1904; **4** (3): 60-66.
- Ibragimov FI, Ibragimova VS. Basic drugs in Chinese medicine. Moscow: Medgiz, 1960.
- Schreter AI. Medicinal flora of the Soviet Far East. Moscow: Medicine, 1975.
- Yuan Z, Xie Y. Illustrated encyclopedia of Chinese herbal medicine. Peking: Zhong yi guji chubanshe, 2009.
- Elyashevich EG, Buzuk GN. Use of medicinal plants is one of the oldest treatments in the mankind history. *Bull Pharm* 2010; **2** (48): 61-64.
- Swapna MM, Prakashkumar R, Anoop KP, Manju CN, Rajith NP. A review on the medicinal and edible aspects of aquatic and wetland plants of India. *J Med Plant Res* 2011; **5** (33): 7163-7176. doi: 10.5897/JMPRx11.005. <http://dx.doi.org/10.5897/JMPRx11.005>
- Chotchoungchatchai S, Saralamp P, Jenjittikul T, Pornsripongse S, Prathanturug S. Medicinal plants used with Thai Traditional Medicine in modern healthcare services: A case study in Kabchoeng Hospital, Surin Province, Thailand. *J Ethnopharmacol* 2012; **141** (1): 193-205. doi: 10.1016/j.jep.2012.02.019. <http://dx.doi.org/10.1016/j.jep.2012.02.019>
- Vasudeva N, Yadav N, Sharma SK. Natural products: A safest approach for obesity. *Chin J Integrative Med* 2012; **18** (6): 473-480. doi: 10.1007/s11655-012-1120-0. <http://dx.doi.org/10.1007/s11655-012-1120-0>
- Chen YD, Ma XT, Du YF. The Chinese Aquatic Plants. Zhengzhou: Henan kexue jishu chubanshe, 2012.
- Liao CH, Lin JY. Purified active lotus plumule (*Nelumbo nucifera* Gaertn) polysaccharides exert anti-inflammatory activity through decreasing Toll-like receptor-2 and -4 expressions using mouse primary splenocytes. *J Ethnopharmacol* 2013; **147** (1): 164-173. doi: 10.1016/j.jep.2013.02.028. <http://dx.doi.org/10.1016/j.jep.2013.02.028>
- Lin RJ, Wu MH, Ma YH, Chung LY, Chen CY, Yen CM. Anthelmintic activities of aporphine from *Nelumbo nucifera* Gaertn. cv. *Rosa-plena* against *Hymenolepis nana*. *Int J Mol Sci* 2014; **15** (3): 3624-3639. doi: 10.3390/ijms15033624. <http://dx.doi.org/10.3390/ijms15033624>
- Mikheev AA. Sacred lotus *Nelumbo nucifera* in Azerbaijan. Baku: Publishing House of the Society of Azerbaijan Survey, 1929.
- Lebedev NN. Finding *Nelumbo nucifera* Gaertn. in the Volga delta. *Botanical J* 1907; **2**: 62-63.
- Plant Resources of the USSR: Flowering plants, their chemical composition, use (Family Caprifoliaceae - Plantaginaceae). Leningrad: Science, 1990.
- Tagiltsev YG, Kolesnikova RD, Nechaev AA. Far East plants are our doctor. Khabarovsk: Far Eastern Research Institute of Forestry, 2004.
- Rao GMM, Pushpangadan P, Shirwaikar A. Hepatoprotective activity of *Nelumbo nucifera* Gaertn. Flower: An ethnopharmacological study. *Acta Pharm Turcica* 2005; **47** (1): 79-88.
- Vikrama Chakravarthi P, Gopakumar N, Nair AMC, Joy AD. Assessment of analgesic activity of red and white lotus seeds (*Nelumbo nucifera*) in albino rats. *J Nat Remedies* 2009; **9** (2): 224-227.
- Mongkolrat S, Palanuvej C, Ruangrunsi N. Quality assessment and liriodenine quantification of *Nelumbo nucifera* dried leaf in Thailand. *Pharmacognosy J* 2012; **4** (32): 24-28. doi: 10.5530/pj.2012.32.5. <http://dx.doi.org/10.5530/pj.2012.32.5>
- Velusami CC, Agarwal A, Mookambeswaran V. Effect of *Nelumbo nucifera* petal extracts on lipase, adipogenesis, adipolysis, and central receptors of obesity. *Evidence-based Complementary and Alternative Med* 2013; 145925. doi: 10.1155/2013/145925. <http://dx.doi.org/10.1155/2013/145925>
- Liu SH, Lu TH, Su CC, Lay IS, Lin HY, Fang KM et al. Lotus leaf (*Nelumbo nucifera*) and its active constituents prevent inflammatory responses in macrophages via JNK/NF- κ B signaling pathway. *Am J Chin Med* 2014; **42** (4): 869-889. doi: 10.1142/S0192415X14500554. <http://dx.doi.org/10.1142/S0192415X14500554>
- Noysang C, Mahringer A, Zeino M, Saeed M, Luanratana O, Fricker G et al. Cytotoxicity and inhibition of P-glycoprotein by selected medicinal plants from Thailand. *J Ethnopharmacol* 2014; **155** (1): 633-641. doi: 10.1016/j.jep.2014.06.001. <http://dx.doi.org/10.1016/j.jep.2014.06.001>
- You JS, Lee YJ, Kim KS, Kim SH, Chang KJ. Ethanol extract of lotus (*Nelumbo nucifera*) root exhibits an anti-adipogenic effect in human pre-adipocytes and anti-obesity and anti-oxidant effects in rats fed a high-fat diet. *Nutr Res* 2014; **34** (3): 258-267. doi: 10.1016/j.nutres.2014.01.003. <http://dx.doi.org/10.1016/j.nutres.2014.01.003>
- Sobolevskaya KA. Useful Plants of West Siberia and the prospects for their introduction. Novosibirsk: Science, 1972.

26. Ovodova RG, Golovchenko VV, Popov SV, Ovodov YS, Shashkov AS. Structural studies and physiological activity of lemnar, a pectin from Lemna minor L. *Russian J Bioorganic Chem* 2000; **26** (10): 669-676. <http://dx.doi.org/10.1007/BF02821835>
27. Nikiforov LA, Dmitruk CE. Study of the bioelemental composition of Lemna minor and Lemna trisulca. *Microlements in medicine* 2008; 23-24.
28. Zamoschina TA, Nikiforov LA, Prosekina EY, Tomova TA. Biological activity of alcoholic extracts of duckweed (Lemna minor L.) in relation to the process of inflammation. Bull Tomsk State University. *Biology* 2011; **26**: 73-80.
29. Nikiforov LA, Belousov MV, Fursa NS. Study of amino acid composition of duckweed (Lemna minor L.). *Bull Siberian Med* 2011; **10** (5): 74-77.
30. Vladimirova IN, Georgiyants VA. Biologically active compounds of Lemna minor L. *Chem Pharm J* 2013; **47** (11): 29-31.
31. Pashkevych VY, Yudin BS. Aquatic plants and animal life. Novosibirsk: Science, 1978.
32. Taranhalli AD, Kadam AM, Karale SS, Warke YB. Evaluation of antidiarrhoeal and wound healing potentials of Ceratophyllum demersum Linn. whole plant in rats. *Latin Am J Pharm* 2011; **30** (2): 297.
33. Gupta A, Pandey VN. Herbal remedies of aquatic macrophytes of Gorakhpur district, Uttar Pradesh (India). *Int J Pharm and Bio Sci* 2014; **5** (1): 300-308.
34. Legault J, Perron T, Mshvildadze V, Girard-Lalancette K, Perron S, Laprise C et al. Antioxidant and anti-inflammatory activities of quercetin 7-O-?-D-glucopyranoside from the leaves of Brasenia schreberi. *J Med Food* 2011; **14** (10): 1127-1134. doi: 10.1089/jmf.2010.0198. <http://dx.doi.org/10.1089/jmf.2010.0198>
35. Li H, Li H, Qu X, Zhao D, Shi Y, Guo L et al. Preliminary study on the anti-tubercular effect of Ottelia alismoides (L.) Pers. *Chin J Chin Materia Medica* 1995; **20**: 115-116.
36. Na M, An R, Jin W, Min BS, Yoo JK, Kim YH et al. Antioxidant effects of plant extracts on free radicals and lipid peroxidation. *Nat Prod Sci* 2003; **9** (4): 226-231.
37. Narasimhulu M, Ashalatha K, Laxmi PS, Sarma AVS, Rao BR, Kishor PBK et al. An unusual novel anti-oxidant dibenzoyl glycoside from Salvinia natans. *Nat Prod Res* 2010; **24** (15): 1390-1394. doi: 10.1080/14786410802469488. <http://dx.doi.org/10.1080/14786410802469488>
38. Ali-Eldin Mohamed Abd-Elnabi Egorov MA. Evaluation of the antibacterial effects of extracts derived from susak (Butomus umbellatus) and salvinia (Salvinia natans). *Nat Sci* 2011; **1**: 77-80.
39. Plant Resources of the USSR: Flowering plants, their chemical composition, use (Family Magnoliaceae - Limoniaceae). Leningrad: Science, 1984.
40. Xiangwei Z, Xiaodong W, Peng N, Yang Z, Jiakuan C. Chemical composition and antimicrobial activity of the essential oil of Sagittaria trifolia. *Chem Nat Compounds* 2006; **42** (5): 520-522. doi: 10.1007/s10600-006-0203-6. <http://dx.doi.org/10.1007/s10600-006-0203-6>
41. Adkar PP, Dongare A, Ambavade SD, Bhaskar VH. Research journal of pharmaceutical, biological and chemical sciences: Effect of Trapa bispinosa on HDAC level in animal tissues for its anti-arthritis activity. *Res J Pharm Biological Chem Sci* 2014; **5** (4): 1404-1415.
42. Adkar P, Dongare A, Ambavade S, Bhaskar VH. Trapa bispinosa Roxb.: A review on nutritional and pharmacological aspects. *Advances in Pharmacol Sci* 2014; 959830. doi: 10.1155/2014/959830. <http://dx.doi.org/10.1155/2014/959830>
43. Kang W, Li Y, Gu X, Xu Q, Huang X. Antioxidant activities, a-glucosidase inhibitory effect in vitro and antihyperglycemic of Trapa acornis shell in alloxan-induced diabetic rats. *J Med Plant Res* 2011; **5** (31): 6805-6812. doi: 10.5897/JMPR11.1163. <http://dx.doi.org/10.5897/JMPR11.1163>
44. Mann S., Gupta D., Gupta V., Gupta RK. Evaluation of nutritional, phytochemical and antioxidant potential of Trapa bispinosa Roxb. fruits. *Int J Pharm and Pharm Sci* 2012; **4** (1): 432-436.
45. Kim YS, Hwang JW, Han YK, Kwon HJ, Hong H, Kim EH et al. Antioxidant activity and protective effects of Trapa japonica pericarp extracts against tert-butylhydroperoxide-induced oxidative damage in Chang cells. *Food Chem Toxicol* 2014; **64**: 49-56. doi: 10.1016/j.fct.2013.11.018. <http://dx.doi.org/10.1016/j.fct.2013.11.018>
46. Leskov AP, Kajukova EV, Zajceva SE, Nikitenko AS, Andrejchenko EG. On the chemical composition of Trapa natans L. (Chita region). Botanical Research in the Amur region and neighboring territories. Blagoveshensk: AB BGI FEB RAS, 2005: 107-108.
47. Okonenko VU, Shilov MP, Litvinenko VI, Tihonov AI. The chemical composition of some species of Trapa L. *Plant Resources* 1973; **9** (2): 250-261.
48. Parekh J, Chanda S. In vitro antimicrobial activity of Trapa natans L. fruit rind extracted in different solvents. *Afr J Biotechnol* 2007; **6** (6): 766-770.
49. Biswas KK, Faruk MO, Amin MZ, Shaha RK. Antibacterial activity of two varieties of water chestnuts (Trapa sp.). *J Bio-Sci* 2012. **20**: 115-123. doi: 10.3329/jbs.v20i0.17725. <http://dx.doi.org/10.3329/jbs.v20i0.17725>
50. Voloshinov A. Brief extraction from Caucasian legends about the plant Jenny-Yashtrom (devil's nuts). S.-Petersburg: Type. N. Tiblena, 1891.
51. Yasuda M, Yasutake K, Hino M, Ohwatari H, Ohmagari N, Takedomi K et al. Inhibitory effects of polyphenols from water chestnut (Trapa japonica) husk on glycolytic enzymes and postprandial blood glucose elevation in mice. *Food Chem* 2014; **165** (15): 42-49. doi: 10.1016/j.foodchem.2014.05.083. <http://dx.doi.org/10.1016/j.foodchem.2014.05.083>
52. Shirshova TI, Chadin IF, Volodin VV. Biologically active substances in aquatic plants of the genus Potamogeton (Potamogetonaceae). *Advances Modern Biology* 2012; **132** (4): 401-415.