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Full Length Research Paper

Nutraceutical Value of Aquatic Plants

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ABSTRACT

Rajasthan has several water bodies. Plants providing edible fruits, seeds, grains, tubers, rootstocks, tender stem and leaves belonging to 47 aquatic species have been studied. The arrangement of taxa is according to Benthan & Hooker's system of classification at the family level, while genera and species are enumerated in an alphabetical sequence. Local names, period of availability, habit and habitat of the plants have been mentioned as use. Main chemical contents of edible parts have also been recorded.

Key words: edible, aquatic species, *medicinal*, habit, *habitat*

1. INTRODUCTION

Rajasthan is the habitat of the aquatic species from roughly one percent of the total angiosperm flora of the world presently. Although Rajasthan is considered desert state but it has rich aquatic flora and biodiversity. Out of an estimated 1,500 species of plants in the state nearly one fifth are aquatics (Pareek, 1996, Razvy, 2011). Reports published exclusively on the aquatic plants of the state are few (Pareek and Sharma, 1988). Some of the reports include Ajit Sagar Bandh (Nair and Kanodia, 1959); Bharatpur (Sarup, 1961), Ghana bird sanctuary (Saxena, 1975); Alwar (Vyas 1962); Kota (Gupta, 1966); Bundi district (Maheshwari and Singh, 1974) and Jaipur district (Sharma and Kumar, 2011, 2012). Pareek (1994a, 1994b) carried out detailed investigations on several aquatic species from Rajasthan. The aquatic habit has been adopted by diverse groups of angiosperms from fresh water to marine. A scientific study shows that out of an estimated 1,500 angiospermic species in the state nearly one fifth are aquatics. The population inhabiting the areas in vicinity of water bodies makes optimal utilization of the hydrophytes.

Reports in literature are there on the uses of plants as food in Wealth of India (1948-76). Rajasthan is frequently subjected to famine, and the study of aquatic vegetation has probably attracted the attention of botanists (Duthie, 1903 - 1921 and Pareek, 1988). They could be potential sources which could be utilized during the time of scarcity as well as in normal days.

During previous investigations edible plants have been reported (Pareek, 1994a). The information furnished here

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is based purely on author's personal observations made during last seven years of studies carried out on the aquatic vegetation of Rajasthan.

2. ENUMERATION OF EDIBLE PLANTS OF AQUATIC HABITAT

Plant species are enumerated under eight broad heads based on the part used. Botanical names are given under respective family followed by local name, period of availability, habit and habitat with other details and its occurrence.

2.1 Fruits Edible

1. *Phoenix sylvestris* (L.) Roxb
Wild date palm Khajar, Khajuri
March- July
Phoenix sylvestris is a tree growing to 15 m (49ft 3in). Suitable for: light (sandy), medium (loamy) and heavy (clay) soils. Suitable pH: acid, neutral and basic (alkaline) soils. The Flowers are hermaphrodite (have both male and female organs). The sap is obtained from the unopened inflorescence which is cut off to obtain sap. The sap can be concentrated as syrup or fermented into alcohol. The sap contains about 14% sugar. The sap plays an important role in the diet of the inhabitants of tribal area of southern Rajasthan. Quantitative determination of the proximate composition of carbohydrate, protein, lipid, minerals and vitamins present in the sap of Phoenix sylvestris has been done by Salvi and Katewa, (2012). The results revealed that sap is a good nutrient supplement and is opulent in carbohydrate, protein, potassium, sodium, vitamin B-complex and vitamin C. The sap of Phoenix sylvestris can be used as good alternative source of health drink and to alleviate hunger and malnutrition.

TRAPACEAE

2. *Trapa bispinosa* Roxb
Synonym of *Trapa natans L. var bispinosa* (Roxb) Makino
October - April
Singhara
Water chestnut is an annual, floating-leaved herb found in freshwater wetlands, lakes, ponds, sluggish reaches of rivers in India. Water chestnut a very variable, rooted aquatic herb, stem elongate and submerged, leaves dimorphic, flowers solitary, white or lilac. Carbohydrate is the major component of this fruit. The fruits are eaten raw or cooked; they are also used for making flour which is used in fast in India.

2.2 Seeds Edible

ASTERACEAE

3. *Xanthium indicum* Koenig
Aadha-Sheesi, Kadoda. "Shankeshwar"
October - April
An annual herb with a short, stout, hairy stem. Leaves broadly triangular-ovate or suborbicular; flower heads in terminal and axillary racemes; white or green; numerous; Fruit oboviod, enclosed in the hardened involucre, with 2 hooked beaks and hooked bristles. The plant of Xanthium yields xanthinin which acts as a plant growth regulator, Antibacterial activity of xanthinin has also been reported. Seed yields a semi-drying edible oil (30-35%) which resembles sunflower oil in bladder infection, herpes, and erysipelas. Cake can be used as manure whereas shell can be used as activated carbon (Oudhia and Tripathi 1998; Sastry and Kavathekar 1990). The plant has been reported as fatal to cattle and pigs edible oil extracted from the seeds.

EURYALACEAE

4. *Euryale ferox* Salisb
Tal-Makhana (Fox nut)
December
Floating- leaved anchored perennials. It is popularly known as "Makhana" in India. It grows in water and plant does not have stem. It has large round leaves and produces bright purple flowers. The whole plant is covered with small thorns. The leaves of fox nut plant have green upper surface and purple shaded lower surface. This plant produces fruits which are about the size of a small orange. Each fruit contains 8-10 seeds which are of pea size, containing proteins, carbohydrates, fat, calcium and phosphorus.

2.3 Grains Eaten as Food

POACEAE

5. *Coix lacryma- jobi* L.
Jargodi
September - December
Emergent anchored annuals. Common in and around marshes, along water courses, and rice fields; culms tufted, leaves linear-lanceolate, spikelets terete or partly flattened, white-yellowish white or bluish grey contains proteins, carbohydrates and minerals.

6. *Echinochloa colonum* (L.) Link
Hema, Sama, Jungli Rice
September - November
Annuals found near water bodies. The seed can be cooked as awhole or ground into flour and used as a mush or porridge young plants and shoots raw or cooked, eaten raw with rice.

7. Echinochloa crusgalli (L.) Beauv.
Sama
September - November
Semi hydrophytic annuals. It can be cooked as a whole or be ground into flour before use. It has a good flavor and can be used in porridges, macroni, dumpling etc. young shoots, stem tips and the heart of the colum-raw or cooked. Young shoots are eaten as raw or cooked vegetable.

8. *Hygroryza aristata* (Retz.) Nees
Janglidal
September
Annual floating glabrous grass; culms creeping or trailing, floating, rooting at internodes, leaf sheath inflated, inflorescence a pyramidal panicle and spikelets solitary. Grains are eaten by poor people (Cook, 1996). They are reported to be sweet, digestible and cooling and useful in biliousness. Grains are gathered and eaten by the poor.

9. *Ischaemum rugosum* salisb.
September- October
A tufted, erect, annual grass with flat, glabrous or sparsely hairy leaves and oblong grains. The grains are eaten at times of scarcity. Analysis of the plant at flowering stage revealed the presence of considerable amount of protein, carbohydrate etc. (Wealth of India, Vol. V); Common in wet places and in rice fields, grows in standing water also.

10. *Oryza rufipogon* Griff.
Jangli-Dhan
September - November
An Erect tufted Emergend annuals shrubs it is considered a weed in rice fields. Common wild rice or in the ancestor of cultivated rice (o. satival). The seeds are edible.

11. *Oryza sativa* L.
Dhan, Chaval
October
An emergent annual or perennial grass without a rhizome; leaf blades linear, spikelets persisting, caryopsis oblong, cylindrical, whitish yellow, brown to

reddish brown. It is one of the oldest of food crops and the basic diet of over half the world's population. The grain is used to make a wide variety of dishes and as stock food. It is fermented to make rice wines. Oil is extracted from the husk and it has a high vitamin B1 content and is used in the treatment and prevention of beri-beri. The extensive and exclusive use of polished rice leads to the development of beri-beri which could be reduced by parboiling the rice before milling and then under-milling (Usher, 1984).

12. *Paspalum scrobiculatum* L.
Kodo, Kodra
August - October
Annual herbs found near water bodies, is a millet largely used by the working and poorer classes of people in all parts of India as a staple article of food. It is not a very commonly used cereal. It resembles larger grains of rava (semolina) but is healthier than rava since it is unrefined and also has a low glycemic index. The dehusked grain is often reported to be poisonous to animal & man when used a food and several cases of poisoning have been reported. The seeds are used as human food grains are ground into meal and used for puddings.

2.4 Tubers and Root-Stocks Cooked as Vegetable

ASTERACEAE

13. *Eclipta prostrata* (Linn.) Linn.
Jal bhangro, "Bhangra" Bhringaraj.
Throughout the year.
Usually annual but also in very wet conditions, it will perennate by rooting at the nodes, commoninand along the edges of pools, tanks, canals, ditches and rice fields; diffuse or ascending herbs, stem and leaves sparsely strigose with bulbous based hairs and the head is white. The leaves are used as vegetables; they are used in some parts of India, in chutneys.

CYPERACEAE

14. *Cyperus esculentus* L.
Chchoda kaseru
Throughout the year
Dry phase pernnials. Source of potara for softening and flavoring green leafy vegetable. Some time called Earth almond or Chufa has Tubers roots that can be eaten raw or cooked usually roasted. Dried ground tubers were used to extend coffee and chocolate Tubers. Rich in oil, carbohydrate, starch, and minerals.

15. *Cyperus rotundus* L.
Mutha, Motha
August - October
Pestifcrous herbs containing essential oil.
Rhizome stoloniferous, leaves few basal, inflorescence simple or compound, spikelets compressed, brown; Perennial, found on river banks, dried up pools and ditches and in rice fields. Tubers are collected, roasted and eaten. The tubers contain cyperene, cyperone, cyperol and 1-pinene which are used for spasms or as an emmenagogue.

16. *Eleocharis dulcis* Trin. ex Hans.
September - November
Gregarious in shallow water in ponds, rice fields and along irrigation canals; Rhizome short with long stolons bearing subglobose tubers, culms terete, leaves reduced to bladeless sheets, inflorescence with a single spikelet, spiketel as wide as culms. It is cultivated for its edible tubers. The above ground parts are high in protein and low in fiber. It has been recommended to be cultivated for its leaf proteins. The corms are rich in

carbohydrates, especially starch and are a good source dietary fiber, riboflavin, Vitamin.

CYPERACEAE

17. *Scirpus grossus* L. F.
September - November
In portions of India, in time of famine the rost annuals found near water bodies in portions of India In time of famine the root in eagerly dug for human food. The fibers and dark cuticle being removed, the solid part of the root in dried, ground and mode into bread, a little flour being some times mixed with it.

POLYGONACEAE

18. *Polygonum plebeium* R.Br.
August - March
Widely distributed; forms dense prostrate mass in rivers, canals and drying out pools; diffusely branched, very variable, sub erect or prostrate under shrubs with a woody rootstock, ochrea lacerate, flowers in axillary cluster, perianth rose. It is used as a vegetable. Powdered herb is given for pneumonia and the rootstock is used against bowel complaints (Wealth of India, Vol. VIII)

MOLLUGINACEAE

19. *Glinus oppositifoilus* (Linn.) A. DC.
August - April
Annuals, found along open areas, lake shores, stream banks; prostrate herbs, leaves in apparent whorls, flowers white in axillary fascicles. The leaves are used as vegetable for cooking purposes, as well as an expectorant and antipyretic agent (Sahakipichan *et al.*, 2010).

NELUMBONACEAE

20. *Nelumbo nucifera* Gacrtn.
Kamal
September - May
Floating- leaved anchored perennials cultivated as a crop, found growing in ponds, tanks, etc; A handsome aquatic herb with stout, creeping rhizome, leaves peltate, glaucous, petioles long, smooth or with small prickles, flowers large, white or rosy. The fruiting torus is sold for the edible carpels embedded on it and are considered superior to cereals in nutritive value. Nelumbo honey is much in demand. Rhizomes are eaten as vegetable or preserved in sugar. The seed kernels are also used as a source of starch or eaten dry (Usher, 1984). The peduncle and petiole are cut into small pieces, dried and fried in oil is a delicious food item and is sold in the name, 'vattal' in Kerala (Pers. Obs. Swapna) Creeping rhizomes contains protein. fat, carbohydrates, calcium, phosphorus and iron.

NYMPHAEACEAE

21. *Nymphaea nouchalli Burmt.*
Kanval, Pappa Phool, Bhmbher
August - April
Floating-leaved anchored perennials. All Parts of the plant are eaten in times of scarcity. The rhizome is considered demulcent and used for dysentery and dyspepsia. Rhizomes contain starch, proteins, and yield grade fiber.

22. *Nymphaea pubescens* willd.
Nil kamel, Nil Padhma, Chota Kamval
August - March
Floting-leaved anchored perennials. Seeds contain proteins, carbohydrates, fat and yield fiber.

2.5 Tender Stem and Leaves Cooked as Vegetables

AMARANTHACEAE

23. *Alternanthera sessilisl* R. Brown ex DC.
August - March
Found in seasonally water logged soil, but prostrate, often ascending, annual perennial herbs particularly common at the edges of tanks, rivers, canals and ditches; young shoots and leaves are eaten as a vegetable (Scher, 2004). The leaves are eaten usually with fish, with rice. The leaves are boiled and ingested to treat hypertension.

CONVOLVULACEAE

24. *lpomea aquatica* Forsk.
Nali-ka-sag
September - March
Floating-shoot perennials usually floating on stagnant water but sometimes found in the banks of pools, canals and rivers; an aquatic, trailing or floating, herbaceous perennial with long, hollow stem rooting at the nodes, flowers white or pale purple with dark purple eye. The young terminal shoots and leaves are used as vegetable and in salad. The stems are sometimes picked. Dried juice has purgative properties. Leaves and stems are said to be cooling.

25. *Limnopila indica* (L.) Druce
Cultra
September - October
Emergent anchored annuals. Aerial stems erect or creeping below, with or without eglandular hairs, heterophyllous, flowers pedicellate, soliatary, white, pale yellow or blue-purple. Leaves eaten as vegetables Juice of aerial part of plant with ginger and cumin is prescribed to cure dysentery.

PONTEDERIACEAE

26. *Monochoria hastata* (L.) Solm
Flowering - August
A perennial herb grows in clumps at the edges of pools, tanks and canals and in ditches. Attains a height of 2 to 3 in during the rains, adjusting its height with the rise in water level; Plant with elongate, creeping, spongy rootstock, leaves long peioled, sagittate, hastate, flowers purplish blue or violet. Tender stalk and leaves are eaten as vegetable.

MENYANTHACEAE

27. *Nymphoides hydrophylla* (Lour) O. Ktze
Tagarmul. Cwnuda, chuli ghainchu
October - April
Stem and leaves are eaten. Floating-leaved anchored perennials deeply rooted in mud in lakes, tanks and temporary pools and in slowly flowing water; plant with long floating stem rooting at the nodes, leaves purplish beneath, flowers white, yellow within. Stems, leaves and fruits are eaten.

ARACEAE

28. *Pistia stratiotes* Linn.
September - May
Free floating rosettes herbs with emergent leaves in tanks, lagoons and rice fields. Forms a dense mat on water surface and cause serious clogging of water ways; a floating stolonlferous herb, leaves sessile, densely pubescent, flowers creamy white, minute and sessile on a spadix. Plant is eaten, in times of famine, Young leaves are cooked and eaten. Used as an antiseptic, antidyscentric, insecticide, and for ear complaints.

29. *Remusatia vivipara* (Roxb.) Schott.
flower not found
Tuberous Perennials bulbiferous herbs occurring in moist places. It is an economically important monocotyledonous flowering plant. Tender shoots eaten as vegetable & good source of antioxidants. The leaves & tubers being edible parts are used in monsoon by local people and are believed to have medicinal values. Therefore the presence of phytochemicals may indicate the medicinal as well as edible value of this epiphytic plant. The plant indicated the presence of reducing sugars, flavonoids, terpenoids & alkaloids.

ASTERACEAE

30. *Sphaeranthus indicus* Linn.
October - April
Automatic herbs, Common in and around irrigation ditches and rice fields; prostrate/ascending; branched from the base, stems with toothed wings flowers in heads and purple in color. The leaves are eaten as a pot herb. The juice of the plant is styptic and said to be useful in liver and gastric disorders. The Plant cooked in butter, flour and sugar is a tonic and fried or boiled seeds are used as an aphrodisiac. The stem with leaf is chewed to get relief from toothache.

SPHENOCLEACEAE

31. *Sphenoclea zeylanica* Gaertner
Flowering- October
Found in swampy areas, along the banks of water courses and in rice fields; an erect annual herb, inflorescence a dense terminal spike with small, greenish yellow flowers. The young plants and tips of older plants are streamed and eaten as vegetable with rice, (Usher, 1984).

CHENOPOSDIACEAE

32. *Suaeda fruticosa* (L.) Forsk.
Lunki, Lunak.
September - March
Salty flavor perennials occur in moist places. Young leaves - raw or cooked. The plant is rich in potassium and in often burnt as a source of potash for making soap & glass seed - raw or cooked.

33. *Suaeda maritima* (L.) Dumort
Khari Lani
March - July
Annuals or perennials occur in moist places. A pleasant juicy flavor, they make a nice addition in small quantities to a salad. They are often mixed with other vegetables in order to reduce their saltiness young leaves-raw or cooked. The young shoots are picked in vinegar & eaten on their own or used as a relish. Seed-raw or cooked. Contains protein, fat, carbohydrates, calcium & phosphorus.

POLYGONACEAE

34. *Rumex crispus* L.
December - August
Perennial herbs leaves-raw or cooked, they can also be dried for later use, the leaves can be added to salads, cooked as a Patherb or added to soups. The leavers are very rich in vitamins A & C. Stam-raw or cooked. They are best peeled and the inner portion eaten. Seed-raw or cooked. It can be used as pinole or can be ground into a powder and used as flour for making pancakes etc. The roasted seed has been used as a coffee substitute.

35. *Rumex dentatus* L.
Ambavah amrule
December - August
Dry phase perennials and rich source of calcium, beta carotene & vitamin C.

Contains protein ether extract, carbohydrates, calcium, phosphorus iron and vitamin A & C. Plants can contain quite high levels of oxalic acid, the IV & should not be eaten in large amounts since the oxalic acid can lock-up, thus causing mineral deficiencies. The oxalic acid content will be reduced it the plant is cooked.

AIZOACEAE

36. *Trianthema portulacastrum* L.
August - November, rarely March - April
Bawara, pathor chatta, kala Satta
Perennials occur near water bodies. Eaten as a leafy vegetable, good source of iron and calcium an excellent source of phosphorus. Rich in proteins, carbohydrates, and ascorbic acids.

37. *Veronica anagallis-aquatica* L.
Water speedwell
January - April
Annuals occur in moist places. Eaten as leaves or cooked, rich in vitamin C. A subtle flavor, the leaves can be added to salads or used as a potherbs when used in salads they go better with a lemon dressing than vinegar. The leaves are often available in winter.

HYDROCHARITACEAE

38. *Vallisneria spiralis* Linn.
September- April
A submerged, tufted, dioecious aquatic herb, stem very short, leaves totally submerged, linear, varying in length with the depth of water young leaves are eaten in salads. They are rich source of phosphorous, calcium and iron and the plant is used as a stomachic and for lecorrhoea (Wealth of India, Vol. X)

2.5 Pods Cooked as Vegetable

MIMOSACEAE

39. *Neptunia oleracea* Lour
Lajalu (Pods) water mimosa
August
Floating shoot anchored annuals. The plant is grown as a vegetable. The leaves & young shoots are said to have a nutty cabbage-like flavor and can be eaten raw or cooked. The fresh stem of this plant can be used for propagation.

2.6 Young Shoot, Infl, Orescence and Rhizome Hydrophyllaceae

40. *Hydrolea zeylanica* Vahl
Young shoots are eaten as vegetable and are reported to have antiseptic properties and are used in medicine (Cook, 1996). Young leaves are eaten with rice.

POLYGONACEAE

41. *Polygonum glabrum* Willd.
Gregarious along water dark down shiny. The young shoots and roots are cooked with vegetables.

HYDROCHARITACEAE

42. *Ottelia alismoides* Persoon
Succulent, flaccid, aquatic herb, leaves totally submerged, flowers white, polygamous, but in India, mostly bisexual, fruit ovoid to cylindrical, seeds densely covered with whitish unicellular hairs. The immature inflorescence is used as food (Cook, 1996). The starchy rhizomes and pollen are also eaten. The rhizomes are astringent and diuretic, and are reported to be deployed in dysentery. The leaves, petioles and inflorescences possess an excellent flavor and are eaten.

TYPHACEAE

43. *Typha angustata* Bory & Chaub.
Patera
August - April
Emergent anchored perennials, several parts of the plant are edible including during various seasons the dormant sprouts on roots and bases of leaves. The inner core of the stack is composed of green bloom spikes, ripe pollen, and starchy roots. The stem is also edible. Contains oil and solid acid viz. palmetic, stearic and other higher saturated acids.

44. *Typha elephantina* Roxb
Mothitrina bora
August - April
Emergent anchored perennials. The fiber contains cellulose, hemi cellulose, lignin and wax.

APIACEAE

45. *Centella asiatica* (L.) Urban
Brahmi-buti, Khulakhundi, Brahma Manduki
October - April
Dry phase perennials widely distributed; a prostrate perennial aromatic herb growing wild along stream sides, paddy fields and other wet places stem reddish, leaves in rosettes, inflorescence single and auxiliary umbel. Fresh plant dissolved in dry vegetable preparation or salad is used to increase memory power. It is also commonly used as porridge for feeding pre-school children in combating nutritional deficiencies (Cox *et al.*, 1993).

BRASSICACEAE

46. *Rorippa Indica* (L.) Hiem
December - April
An annual herb of ca 12 cm long with leaves of about 5-10cm, hairy and variously lobed. Flowers are very small. Tender young leaves & stems -raw or-cooked as vegetable containing 5% proteins.

PONTE DERI ACEAE

47. *Monochoria vaginalis* (Burm. F.) Presl.
July - September
Emergent anchored perenials. Tubers leaves and aerial parts are eaten, raw or cooked. Tender stalk, leaves & entire plant except the roots eaten as vegetable. Nutritional evaluation suggests the plant can be an alternative nutrient rich leafy vegetable.

3. DISCUSSION

The above enumeration reveals that the water-bodies in the State comprise very few perennial rivers and rivulets, numerous seasonal 'nalas' a number of artificial reservoirs, irrigation canals, ponds and puddles. Some of these are purely seasonal. In some cases water persists for most of the part of the year. Some artificial reservoirs controlled by the irrigation department may, however, retain water for a longer period.
About 47 species of aquatic habitats belonging to 39 genera and 25 families provide food to the human population.
The habit analysis reveals that about 27 and 19 species are perennials and annuals respectively and only one species of Suaeda i.e., Suaeda maritima is reported to both (annual/ perennial) habits.
The aquatic plants have been categorized in different ways by different workers from time to time. The author has followed the classification given by Daubenmire (1947) and grouped the aquatic of Rajasthan in the 8 categories on the basis of their habit and habitat:

Free floating	02
Submerged	00
Submerged anchored	01
Floating anchored	06
Floating shoot anchored	02
Emergent anchored	08
Wetlands	21
Dry Phase	07
Total	47

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