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Aquatic plants and marine waste as animal feed

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Abstract: Aquatic plants and marine waste can be used as animal feed. Water hyacinth, azolla and water spinach are the popular aquatic plants that are used as animal feed. Feed from marine sources include sea weed and different type of marine waste meals. Since the nutritional profile of aquatic and marine source of animal feed is less known, this article reviews the availability, chemical composition and feeding level in different animals.
Keywords: water hyacinth, azolla, water spinach, sea weed

INTRODUCTION

Aquatic plants are plants that have adapted to live in aquatic environments i.e. either salt water or fresh water. They are also known as hydrophytes or macrophytes. Aquatic plants are categorized as floating, submerged or emergent varieties. These plants have various adaptations to get submerged in water or in the water surface. Common adaptations are aerenchyma, floating leaves and finely dissected leaves. Aerenchyma is a spongy tissue that forms spaces or air channels in the leaves, stem and root that allows exchange of gases between shoot and root. Aquatic plants are generally considered as pollution on water bodies. Now a day's public concern had increased over the availability of aquatic weeds and other marine plants as livestock feed. Aquatic weeds differ widely in their chemical composition depending upon species, season and location. So this article discusses the features of different aquatic and marine plants that can be used for feeding livestock.

Aquatic plants as animal feed

Most popularly used aquatic plants for feeding animals include water hyacinth, azolla and water spinach. Other aquatic plants commonly used include lotus (*Nulembo nucifera*), water fern (*Salvinia auriculata*), hydrilla, water lettuce (*Pista stratiotus*), water chestnut (*Trapa bispionsa*), tape grass (*Vallisneria spiralis*), alligator weed (*Alternanthera phoiloxeriodes*), day flower (*Commolina bengalensis*), knot weed (*Polygonum barbatum*), cat tail (*Typa latifolia*), water lilly (*Nymphaea stellata*) etc.

Water hyacinth (*Eichornia crassipes*)

Water hyacinth belongs to the family Pontederiaciae. Normally water hyacinth has habitat at tropical and subtropical countries but actually it is a native of Brazil. Mainly two varieties of water hyacinth are found i.e. long and dwarf varieties. Water hyacinth had a yield of 150 MT/ha/yr. Water hyacinth is highly invasive in nature and its rapid growth and propogation causes great problems. Water hyacinth is considered as a weed in more than 50 countries. Water hyacinths do not occur in water with average salinities greater than 15% that of sea water.

Table 1: Chemical composition of water hyacinth

Chemical composition (g/100g DM)	DM	CP	NDF	ADF	ASH	EE	NFE	ME(Kcal/kg)
Water hyacinth	9.3	10.5	63.5	33.7	12.4	1.5	48.7	2032.6

(Modified from [10])

Potential degradability of water hyacinth was found to be 68.09%, 60.82% and 52.91% for leaves, shoots and whole plant respectively [1]. Water hyacinth showed rumen digestibility of 48%. Leaf proteins of hyacinth are rich in glutamine, asparagine and leucine. Immature plants have higher protein compared to mature ones. High content of lignin, silica and ash also noticed in water hyacinth [10].

Water hyacinth is an excellent source of feed for ruminants. Water hyacinth contains high amount of cellulose and hemi cellulose which acts as an energy source for ruminants [19]. It can be fed in the wilted

form along with dry roughages. Water hyacinth can be ensiled and these ensiled water hyacinths were accepted by ruminants. Water hyacinth ensiled with rice straw, urea and molasses found to improve milk production in cattle [4]. Water hyacinth is not a sole feed but it can replace 50% of concentrates in complete feed. Water hyacinth residues can also be used after mechanically extracting the juice. Improvement of crude protein intake and digestibility has been seen when increasing levels of fresh Eichhornia crassipes was incorporated in cattle diets [30]. However, to avoid bloat and low intake of rice straw, the level of fresh water hyacinth in diet should not exceed 30% for growing cattle [10].

Water hyacinth also proved to have good effect in the diet of non-ruminants. It was found that in pigs the use of concentrate can be reduced upto 6% by using water hyacinth in diet [17]. Replacement of para grass with water hyacinth up to 60% in rabbit diets improved feed utilisation, growth performance and economic returns [31]. Water hyacinth in duck diets (15%) gave higher daily feed intake, egg laying ratio and egg quality compared to the unsupplemented control diet [14].

Eventhough water hyacinth is proved to be having lot of advantages, on contradictory its having so many limitations also. It contains HCN, alkaloids and triterpinoid and thus it may induce itching. Presence of higher amount of sodium and potassium hamper the magnesium balance and it results in symptoms of diuretics. Palatability of water hyacinth was found to be low and it may be due to the high raphide (bundle of needle shaped crystals of calcium oxalate) content. Presence of higher amount of heavy metal also is a disadvantage. Water hyacinth roots naturally absorb pollutants including lead, mercury and strontium in concentrations 10,000 times that in the surrounding water.

Azolla

Azolla is a floating fern which resembles algae. Azolla belongs to family azollaceae. Azolla is also popularly known as mosquito fern, duckweed fern, fairy moss and water fern. Normally azolla grows in paddy fields or shallow water bodies. It multiplies very rapidly. Azolla doubles its biomass within 3-10 days and can reach 8-10 tonnes fresh matter/ha in Asian rice fields. Azolla hosts symbiotic blue green algae, *Anabaena azollae*, which is responsible for fixation and assimilation of atmospheric nitrogen. An azolla plant is a fern frond consisting of a main stem growing at the surface of the water, with alternate leaves and adventitious roots at regular intervals along the stem. Secondary stems develop at the axil of certain leaves. Azolla fronds are triangular or polygonal and float on the water surface individually or in mats [15].

Table 2: Chemical composition of Azolla

Nutrient	**%DM**
Crude protein	21.4
Crude fibre	12.7
Ether extract	2.7
Ash	16.2
NFE	47.0
Cell wall fraction	
Neutral detergent fibre	36.88
Acid detergent fibre	47.08
Hemicellulose	10.20
Cellulose	12.76
Lignin	28.24

(Modified from [2])

Azolla production can be easily done in an artificial water body prepared with the help of a silpauline sheet. Pit size should be around 2m x 2m x 0.2m. Slurry made of 2 kg cow dung + 30 g of Super Phosphate mixed in 10 litre of water is poured and raise water level to about 10 cm in the pit. About 0.5 - 1 kg of fresh and pure culture of azolla is placed in the water. This will grow rapidly and fill the pit within 10 - 15 days and 500-600 g azolla can be harvested daily [15]. Once in 5 days 20g super phosphate and 1 kg cow dung had to be added. Once in every 10 days about 25-30% of water had to be replaced to prevent nitrogen build up in the bed.

Azolla normally mixed with commercial feed in the ratio of 1: 1 to feed the livestock. It can also be fed directly. Dried azolla can also be powdered and mixed in regular feed. Kathirvelan *et al.;* [15] concluded that the increase in the quality and quantity of milk production after azolla feeding is majorly due to the protein content and other components like carotenoids, biopolymers etc more than that of the carbohydrate content. According to the work done by Vivekananda Kendra Natural Resources Development Project, azolla can be fed to adult cow at a dosage of 2 kg/day, layer/broiler bird with 20-30 g/day, goat with 300-500g/day, pig with 1 kg and rabbit with 100g.

According to Dolberg et al., [7], azolla supplemented group of crossbred heifers on a basal diet of wheat straw and sugar cane tops showed higher body weight gain compared to those supplemented with concentrate. Effect of azolla in crossbred female calves studied by Khare [16] found that azolla supplementation improved growth rate, feed efficiency and also reduced the feed cost. Azolla supplementation at 15% in diet found to improve the growth rate in growing fattening pigs [3]. Replacement of soya protein by azolla protein in fattening pigs at 10% found to improve daily gain [8].

Water Spinach (*Ipomoea aquatica*)

Water spinach is a semi aquatic tropical plant having tender shoots and leaves. It is belonging to the family convulvulaceae. Water spinach can grow upto a length of 2-3 metres. It is most commonly seen in East and South East Asia. Fresh biomass yields of up to 24 tonnes/ha in a growth period of 30 days from the sowing time of seed [23].

Table 3: Chemical composition of Water Spinach

%DM	%CP	%ASH	%EE	%CF
9.1	25.7	16.2	2.2	22.8

(Modified from [23])

Water spinach is commonly used as a feed for non-ruminants and rabbits. It does not contain any anti-nutritional factor. Water spinach is having a balanced amino acid array especially in terms of sulphur rich amino acids. When 6% fish meal replaced by water spinach in the diet of pigs fed with water spinach, palm oil and broken rice, an increase in growth rate were observed [24]. Feeding of water spinach alone [28] and concentrate + water spinach [33] in rabbits showed live weight gain of 20g and 31.4 g/d respectively. Important thing to be noticed while feeding water spinach alone to rabbits is that feeding level should not be above 8% of the body weight (DM basis) to ensure that the rabbits consume the stems which have higher fiber content than the leaves [28]. Water spinach is having very high DM digestibility in rabbits. Water spinach is also a rich source of vitamins and minerals. It is rich in vitamins A (carotene), B1, B2 and C and in iron.

Animal feed from marine source

Sea weed is an important feed available from marine source. Sea weeds are macrophytic algae, live in the sea or brackish water. Sea weeds lack true leaves, stem and root. Sea weed is a polyphyletic group since the sea weeds belong to one of several groups of multicellular algae i.e. green, brown and red algae. Chlorophyta (green algae) includes 900 species, phaeophyta (brown algae) includes 1500 species and rhodophyta (red algae) includes 4000 species. Among all this only 140 species were used for food. Sea weed is used as a source of agar. Cultivation of sea weed gives a yield of 20-25 tonnes/hectare/year.

Table 4: Chemical composition of sea weeds in India

	Kappaphycus alverrezii	***Ulva lactuca***	***Gracilaria corticata***	***Gracilaria verrucosa***	***Sorgassum wightii***
OM	52.54	89.94	55.49	65.50	81.64
CP	7.94	17.27	14.12	8.02	9.04
EE	2.44	1.64	1.47	0.55	2.81
NDF	9.99	24.84	17.43	34.12	31.66
ADF	6.57	-	7.8	8.86	47.79
ADL	6.57	-	2.26	2.42	1.03
Ash	47.46	10.06	44.51	34.50	18.36
AIA	1.32	1.07	6.49	5.26	0.95
Ca	1.65	1.62	1.79	2.53	4.80
P	0.12	0.21	0.34	0.14	4.11
S	6.76	1.82	4.62	4.70	2.93
Mg	0.14	0.21	0.11	0.12	0.36

(Source: [28])

Sea weed is a good source of proteins and minerals. Even though the amino acid profile of sea weeds varies according to the species, commonly sea weeds are having high content of phenyl alanine, tyrosine, threonine, tryptophan and valine. Sea weeds can be fed to ruminants and swine. Feeding 30% of seaweed instead of concentrate not alters the milk and fat yields in dairy cow [6]. Singh *et al.;* [29] also done studies by incorporating 20% sea weed in concentrate ration of sahiwal cows and found that it won't negatively affect the milk production and DM digestibility. It was found that up to 15% seaweed inclusion did not affect the intake and body gain in sheep. Gracillaria species of sea weed is used as human food. Sea weeds are having anti-oxidant action. Cvetkovic *et al.;* [5] observed that supplementation of

brown sea weed to heat stressed lactating cattle improves milk yield and milk protein content.

Marine wastes for animal feeding

Marine wastes for animal feeding include crab meat, fish meal, shrimp meal, squilla meal, squid meal, frog meal etc. Crab meal includes well ground dried waste of crab containing shell, viscera and part of flesh. Crab meal is a good source of Ca (16-18%) and P (1.75%). Nicholson *et al.;* [20] observed that low level (12%) of crab meal in diet of beef cattle improves daily weight gain, dry matter intake and feed conversion efficiency. The protein content in crab meal was highly resistant to degradation in the rumen but was well digested in the whole tract of sheep [20]. Hulan *et al.;* [12] reported that crab meal had a good balance of essential amino acids.

Shrimp meal is basically the dried waste of the shrimp industry, consisting of the heads, hulls (or shells) and appendages. Chemical composition of shrimp meal is influenced by the constituents, method of processing and storage [21]. Because of rich presence of carotenoid pigments, shrimp meal can also be used as a colouring and flavouring agent. Fanimo *et al.;* [9] compared fish meal and shrimp meal in growing pigs and observed low growth rate on shrimp meal feeding thus concluded that the protein quality of shrimp meal is inferior to that of fish meal. Shrimp meal is a suitable protein rich concentrate for broilers and layers [32]. Total replacement of fish meal or toasted soya bean meal protein by sun dried shrimp meal protein is not good for broiler growth rate and efficiency [22].

Squilla (*Oratosquilla nepa*) found in abundance along Indian cost, China, Thailand, Malaysia and Philippines. Squilla meal is not consumed by humans. It is having high chitin content (147g/kg DM). Squilla meal can be incorporated in broiler ration. Processing of squilla meal before feeding by enzyme treatment, autoclaving found to improve weight gain in broilers compared to non-processed squilla meal feeding [26].

Frog meal is the byproduct of frog leg industry. *Rana catesbeiana* (American bullfrog), *Rana tigrina* (Indian bullfrog), *Rana esculanta* (green frog), *Rana ridibunda* and *Lexadactyla ocellatus* species of frogs are commonly used for producing frog meal. Frog meal is rich in protein and having high proportion of palmitic acid, oleic acid, linoleic acid content. Frog meal is also rich in minerals and vitamins like Zn, K, Cu, Mg, Mn, folic acid and thiamine.

Table 5: Chemical composition (%) of different marine wastes

Nutrients	Crab meal	Shrimp meal	Squilla meal	Squid meal
DM	92.7	82.38	94.24	93.26
CP	36-48	61.77	38.37	69.19
NFE	-	0.75	18.67	-
CF	17.6-17.9	10.83	4.84	-
EE	1.4-4.2	7.66	5.40	11.58
TA	31.7-41.3	18.99	32.72	20.19
AIA	-	-	8.12	-
Ca	16-18	6.32	8.07	2.45
P	1.75	1.78	1.74	3.43
Reference	[13]	[27]	[18]	[11]

CONCLUSION

As the availability of normal feed stuffs to animals is getting scarce day by day, non-conventional sources of feed had to be explored. Aquatic and marine sources of animal feed are a good field that had to be given more importance for satisfying and fulfilling the extra need of feed. Detailed information had to be developed regarding the nutrient profile of these feed stuffs. Modern biotechnological methods to enhance bioavailability on nutrients from aquatic and marine sources are to be developed for better utilization of these feed stuffs.

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