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NUTRACEUTICAL ASPECTS OF *AZOLLA*: A LOW-COST ORGANIC INPUT FOR LIVESTOCK

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Abstract: Livestock has a significant role in the world economy. Livestock is the major source of livelihood for about 20.5 million people in India and livestock resources contribute 4.11% of the country's GDP and 25.6% of total agriculture GDP. On the other hand, there is a huge gap between demand and supply of feed and fodder in India, which can be reduced by exploring natural feed resources as supplements. To complete the shortage of feed and optimum production of livestock, it is significant to explore some non-conventional nutritive feed resources. The aquatic fern, *Azolla* has been identified as one of the most efficient substitutes for livestock as it can be easily digested due to its low lignin with high protein content having especially essential amino acid lysine. Its unique nutrient aspects make it an ideal feed for livestock, poultry, goat, fish, and pigs. Nutraceutical aspects of *Azolla* bio-feed technology will be taken up in a big way by the dairy farmers, especially, by those who experience land scarce conditions for fodder production.

Keywords: Agriculture, *Azolla*, Bio-feed technology, Livestock, Supplement.

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INTRODUCTION

Livestock refers to domestic animals, which are kept for use or profit (Verma, 2017). It plays a significant role in the world economy. Livestock is the major source of livelihood for about 20.5 million people in India. There are vast livestock resources in India that contribute 4.11% of GDP and 25.6% of total agriculture GDP, even so there is a huge gap between demand and supply of feed and fodder in India which can be reduced by exploring natural feed resources as supplements. The natural resources must be fully explored to promote agriculture production that can reduce dependence on chemical input. At present, the conventional feeds are not quite enough to complete the shortage of feed and fodders to make animal production more viable and productive (Chatterjee *et al.,* 2013). There is about 60% deficiency of green fodder in general. In order to complete the shortage of feed and optimum production of livestock, it is utmost significant to explore some non-conventional feed resources without compromising the nutrient quality of feed.

Azolla is an aquatic fern that freely floats on the water surface (Agnihotri, 2019). The term Azolla is derived from two Greek words azo means to dry and allyo means to kill which depicts the aqueous habit of the plant. *Azolla* is heterosporous and leptosporangiate fern from aquatic and semi-aquatic habitats. The normal habitats of *Azolla* are natural ponds ditches, canals, and paddy fields and where agricultural runoff water is seasonally covered by a thick mat of *Azolla*, with other free-floating aquatic plants such as *Lemna, Riccia, Pistia, Salvinia, Spirodela,* and *Ricciocarpus*.

Azolla (Fig. 1-6) has been identified as one of the most efficient substitutes for livestock feed as it can be easily digested due to its low lignin content and high protein content. Its unique nutrient aspects make it an ideal feed for livestock, poultry, goat, fish, and pigs (Gouri *et al*., 2012). Ambade *et al. (*2010) reported 15-20% increase in yield of cattle milk after feeding *Azolla*. *Azolla* is very rich in proteins, vitamins (vitamin B_{12}), and minerals including calcium, potassium, iron, phosphorous, copper, magnesium etc., as mentioned in table 1. Sanginga and Van Hove (1989) reported that amino acids are the constituent that makes *Azolla* a unique feed supplement. Cohen *et al*. (2002) reported to have an essential component like 3-Deo-xyanthocyanins which are the only known flavonoids of *Azolla* and various antioxidants like phyto-constituents such as tannins, phenolic contents and flavonoids from *Azolla* crude extract.

Azolla has many applications as a bio-fertilizer in agriculture and also has the source of human food, poultry feed, fish feed, and mosquito control. Under ideal conditions, *Azolla* doubles its biomass very rapidly. Due to its high nutritive value, it is known as a green gold mine and super plant. Besides the nitrogen fixation, its development is also responsible for favorable changes in the aquatic medium like prevention of pH changes, lowering of water temperature, suppression of weeds, and mosquito larva. *Azolla* is effective in the biological control of mosquitoes due to its growth as a dense layer on the water surface and preventing mosquito larvae from coming up for inhalation In this article, authors are trying to discuss the azolla bio-feed technology's potential use in future agriculture.

DISTRIBUTION OF AZOLLA

There are at least eight species of *Azolla* worldwide *namely Azolla caroliniana, Azolla microphylla*, *Azolla circinata*, *Azolla japonica*, *Azolla nilotica, Azolla mexicana*, *Azolla pinnata* and *Azolla rubra*. But *Azolla piñnata* is the most commonly found in India. *Azolla* belongs to genus *Azolla*, division Pteridophyta, family Azollaceae and order Salviniales (Nordiah *et al*., 2012). *Azolla* is divided into two subgenera (*Euazolla, Rhizosperma*) and six species (Raja *et al*., 2012). The subgenus *Euazolla* has three megaspore-floats (with septate glochidia) and four species (*caroliniana, filiculoides, microphylla*, and *mexicana)*. The subgenus *Rhizosperma* has nine megaspore-floats and two species, *i.e. Azolla nilotica* (without glochidia) and *Azolla pinnata (*with glochidia). *Azolla* species have sporocarp, involved in the production of spores for reproduction and glochidia has a barbed hair-like appearance that helps in the anchoring of microspore massulae (Schirrmeister *et al*., 2015; van der Burgh *et al*., 2013). *Azolla caroliniana* is distributed from Central to South America and the Eastern part of Andes to Western Europe as well as in the Nile Delta, Egypt (Nierop *et al*., 2011). The *filiculoides* species is cultivated in South Africa, Western America, Western Europe, Australia, and Asia (van Kempen *et al*., 2016). *Azolla mexicana* has shown a little expansion from its indigenous area while *A. microphylla* is mainly confined to the Galapagos Islands (Pereira, 2017). Similarly, an African native species, *i.e. Azolla nilotica* is distributed in South Africa, Eastern Africa, Egypt and (Sadeghi *et al*., 2013). *Azolla pinnata* (including its three sub-species) is distributed in tropical Africa, and Australasia Southeast Asia (Carrapico *et al*., 2000; Brouwer *et al*., 2018).

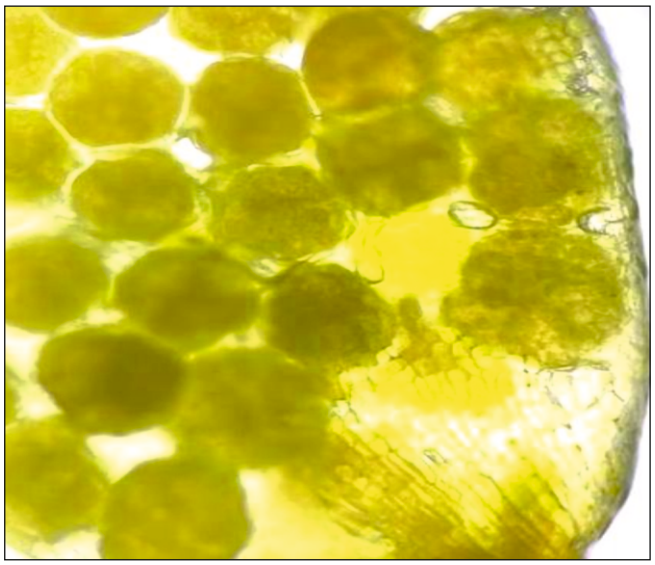

Fig. 1: Sporocarp of *Azolla*.

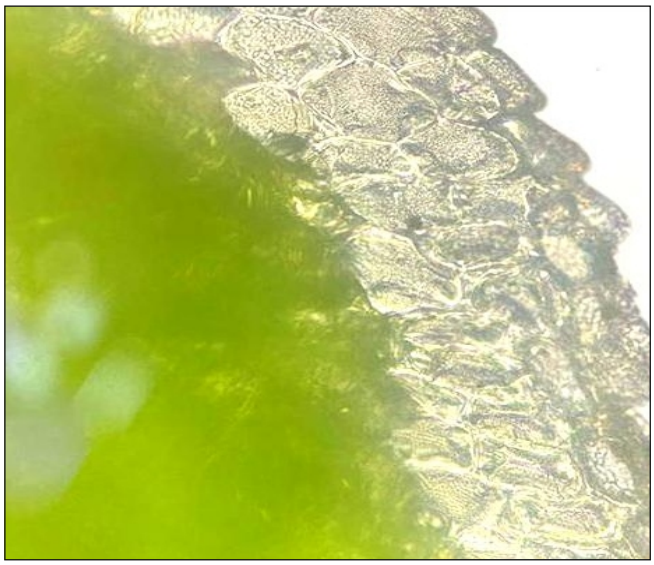

Fig. 2: Fronds under microscope.

Fig. 3: Dividing spores.

Fig. 4: Sporophyll of *Azolla*.

Fig. 5: Green *Azolla*.

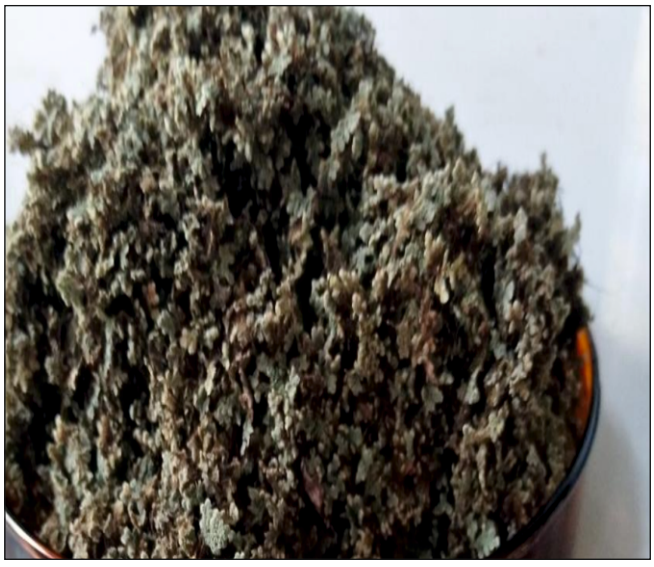

Fig. 6: Dried *Azolla*.

Table 1: Nutrient profile of *Azolla*

S. No.	Nutrient Profile	References
1.	Potential source of protein (25- 35%)	Lumpkin, 1984
2.	Almost all essential amino acids (7-10%) especially lysine	Sanginga and Van Hove, 1989
3.	Essential minerals such as Iron, Calcium, Phosphorous, Magnesium, Manganese, Potassium, and Copper (10- 15%), Vitamins like A and B_{12}	Bacerra *et al*., 1995; Veys *et al*., 1999
4.	Carotenoids, Chlorophyll 'a' and 'b', Bio-polymers, Probiotics, and Growth promoting intermediates	Tamany *et al*., 1992; Pillai *et al*., 2005; Lakshmi and Sailaja, 2012; Mathur *et al*., 2013; Parashuramulu *et al*., 2013; Cherryl *et al*., 2014; Katoch *et al*., 2021

USES AND IMPORTANCE OF *AZOLLA*

1. Importance of *Azolla* in fish pond: *Azolla* can be used in fish pond either directly or indirectly due to its nutrient composition (dry weight) as shown in table 1. It can be used as food in azolla - macrophytophagous fish pond culture. It has been reported that azolla increase the production of fish faeces which act as organic fertilizer in pond. *Azolla* is used as a supplement to natural feed that can reduce the high dependency on fish meal and fish oil. The fish species like rohu, catla, grass carp and tilapia have been reported to convert raw protein from *Azolla* into the best edible protein, thus reduces the cost of production of feeds.

2. Significance of *Azolla* meal: Among published papers reviewed, it was found that in *Tilapia* species (*Oreochromis niloticus, Tilapia zillii, Tilapia mossambica*,) and in the Family of Cyprinidae (*Labeo rohita, Catla catla, Labeo calbasu, Labeo fimbriatus, Barbonymus gonionotus Ctenopharyngodon idella*), *Azolla* was incorporated in their diets. The azolla an aquatic fern has been successfully used in tilapia and carp culture as a source of protein. Authors have been studied the effect on growth, performance and survivability of tilapia fingerlings by using azolla as a component in feed. Most of the literature reviewed reported the increase in performance of fries at the increased dietary content of azolla. According to Sithara and Kamalaveni (2008), biochemical parameters like protein, carbohydrates and lipids contents in liver and muscles were increased when fish fed a diet containing wheat bran, rice bran and azolla in ratio of 25:25:50 for duration of 90 days. The information of effect of azolla as a feed ingredient is summarized in table 2.

3. Use of *Azolla* in poultry: The poultry industry is one of the most profitable business sector in India that provides nutritious eggs and meats for human within the shortest possible time. In poultry, feed is quite expensive input and about 70% of production cost is for feed alone. As feed related improvement in the performance has a profound effect on profitably, the poultry nutritionists have used azolla as alternative cost effective, non-conventional feed ingredients (Fig. 7). *Azolla* feeding in poultry (20-30g/bird/day) reduce consumption of concentrate feed by 13% and can increase egg weight by 6.62% Total protein content, carotene, albumin, globulin, has been reported to increase 12.9%, 8.64%, 3.4%, 9.5% respectively in edible portion of egg. Subudhi and Singh (1978) concluded that green *Azolla* could replace commercial feed by 20% in the diet of young chickens. They reported that to replace this much (20%) commercial feed about 9 kg of fresh *Azolla* would require each day for 100 chickens. The nutrient digestibility is high in case of fresh azolla due to its low lignin content. The information about effect of *Azolla* as a feed in poultry is summarized in table 3.

Table 2: Information about effect of *Azolla* as a feed on different fish species.

Common name	Scientific name	Percentage of Azolla	Results	References
Nile tilapia	*Oreochromis niloticus*	42%	Improvement on growth performance, feed utilization and survival rate on Nile tilapia	Santiago *et al*., 1988
Mozambique tilapia	*Tilapia mossambica*	50%	Protein, carbohydrate and lipid contents in liver and muscles were increased	Sithara and Kamalaveni, 2008
Red breast Tilapia	*Tilapia rendalli*	40%	Highest performance	Micha *et al*., 1988
Rohu	*Labeo rohita*	40%	Higher weight gain and good utilization	Das *et al*., 2004
Orange fin labeo	*Labeo calbasu*	30%	High growth without any adverse effect	Gangadhar *et al*., 2017
Catla	(*Catla catla)*	20%	Performance was high	Umalatha *et al*., 2018
Fringed lipped peninsula carp	*Labeo fimbriatus*	40%	Production was more	Gangadhar *et al*., 2015
Grass carp	*Ctenopharyn-godon idella*	30%	Improved growth	Ayyappan and Ali, 2007
Thai Silver	*Barbonymus gonionotus*	25%	General growth and barb production performance of fish was higher	Das *et al*., 2004

Table 3: Information about effect of *Azolla* as a feed on different poultry species.

Organism	% of *Azolla*	Result	References
Broiler Chickens	5-15%	Improves FCR, energy efficiency and performance	Lejeune *et al*., 1999; Dhumal *et al*., 2009; Namra *et al*., 2010
Layer Chickens	5%-10%	Reported good egg mass output and FCR	Kannaiyan and Kumar, 2005; Lakshmanan *et al*., 2017
Quails	15%	Enhanced the growth and FCR without affecting feed consumption and Carcass traits.	Rathod *et al*., 2013; Varadharajan *et al*., 2019
Ducks	20-40%	No toxic effect of *Azolla cristata* supplementation	Safriyani *et al*., 2020

4. Use of *Azolla* in pig culture: *Azolla* can be incorporated in pig diet 1.2 kg\pig\day during growing phase (30-60kg) and 3.25kg during finishing phase (60-90kg) as soya bean substitute without affecting normal growth rate (Becerra *et al*., 1990).

5. *Azolla* as a feed for Mallards: *Azolla* as a feed for Muscovy (meat production) and Mallard (egg production) ducks has also been a common practice in Vietnam (Katole *et al*., 2017). Becerra *et al*. (1995) conducted trials to determine the effect of feeding *Azolla microphylla* as partial replacement of the protein in boiled soya bean in diets based on sugar cane juice for meat ducks. Fresh *Azolla* was offered three, four or five times per day, at a rate of 1 kg fresh weight per pen at each feeding and the times increased with the age of the birds to minimize losses. The rations were fed from the age of one month to 70 days old.

6. Effect of *Azolla* on Cattle and milk production: Fodder is primary requirement for cattle. Even the animals are fed with various commercial feeds till fresh green grass is available as green fodder that

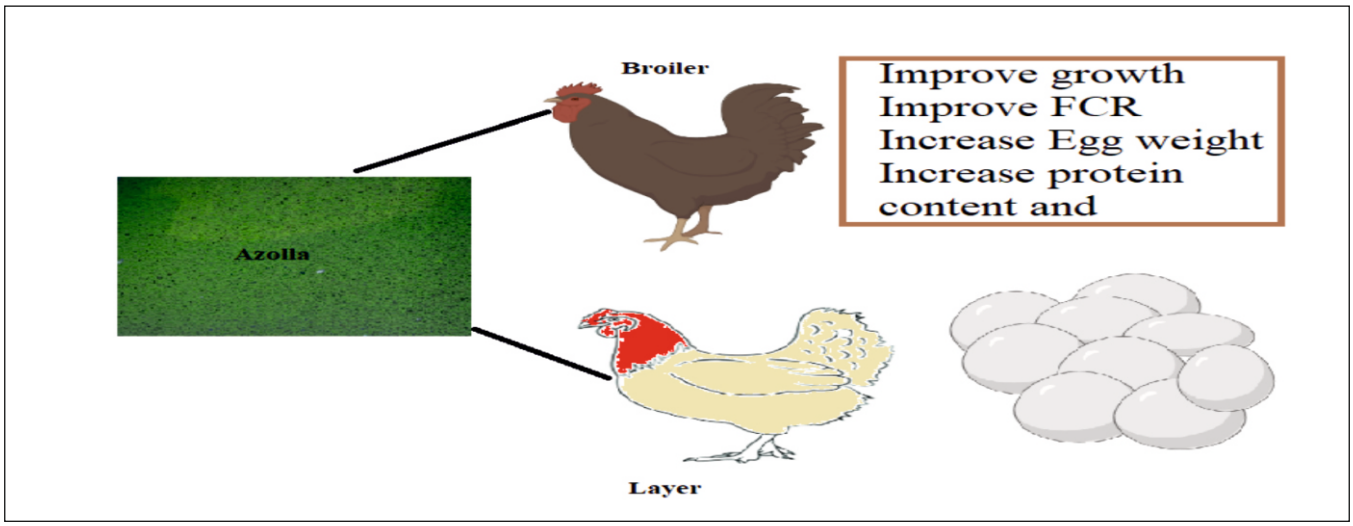

Fig 7: Effect of *Azolla* on broiler and layer.

can greatly reduce the expenditure on commercial feeds (Chethan *et al*., 2021). The success of dairy farmers depends mainly on increasing milk production without increase in feeding cost. Thus, growing azolla is a good option to reduce the cost. *Azolla* is a highly productive plant. *Azolla* can double its biomass within 3-10 days, depending on climatic conditions, and yield can reach up to 8–10-ton fresh matter/ha in Asian rice fields. In India, yields of 37.8-ton fresh weight/ha (2.78 t DM/ha) have been reported for *Azolla pinnata*. *Azolla* inclusion in cattle 2kg/per/day feed increase milk production up to 30%, improve milk quality and animal health.

CONCLUSION

Azolla can be used as a novel feed supplement or substitute for pig, cattle, fish, and poultry, apart from its utility as a bio-fertilizer for wetland paddy. *Azolla* bio-feed technology will be taken up in a big way by the dairy farmers, especially, by those who experience land scarce conditions for fodder production.

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