COORDINATED APPROACHES FOR ANIMAL HEALTH AND PRODUCTIVITY

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Azolla - An alternate feed resource for chicken and ducks

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Introduction

Poultry industry plays an important role in agricultural sector which provides nutritious meats and eggs for utilization in human beings. India ranks 3rd in poultry egg production and 5th in poultry meat production (Singh, 2022). In duck population, India ranks second in world with a total duck population of around 23.5 millions according to the livestock census of India, 2012 (Swain et al., 2020). Duck egg and meat are preferred by people next to chicken and has demand in market. However, supply of quality feed at a rational price can make the poultry production more remunerative (Basak et al., 2002). The per capita availability of egg is about 74 and meat is 2.8 kg against annual requirement of eggs and meat of 180 eggs and 11 kg poultry meat, respectively recommended by ICMR (Kumar and Pandey, 2019); and thus, there is a wide gap between the demand and supply. The main constraints in the production of poultry are the exorbitant cost of feed ingredients, particularly of maize and soybean meal due to the competition between human beings and livestock for these commodities. Poultry production plays a major role in bridging the protein gap in developing countries where the average daily consumption is far below the recommended standards (Onyimonyi et al., 2009). Productivity of poultry in tropics has been limited by scarcity and consequent high prices of the conventional protein sources which are limiting factors for poultry feed production (Atawodi et al., 2008). Hence, search for alternatives feed resources has become inevitable to reduce the use of these conventional feed ingredients to minimise the competition with human beings and to optimise feed cost to make the poultry products competitive in the market. Food and Agricultural Organization also focuses on expanding the feed base through increased use of locally available feed resources in developing countries (Sansoucy, 1993). One probable source of cheap protein for poultry is the leaf meal some tropical and legume plants (Iheukwumere et al., 2008).

The green plants are the most prospective and cheapest protein sources due to their ability of amino acids synthesis (Fasuyi and Aletor, 2005).Further, aquatic plant species are better protein sources than tree leaves as they do not appear to accumulate secondary plant metabolites (Bacerra et al., 1995). Among the various aquatic plant species, azolla (*Azolla pinnata*) provides a sustainable feed for poultry.

Production of azolla

The method of producing and managing Azolla particularly *Azolla pinnata* is systematically described (Anonymous, 2014-15 and 2015-16). A water body is made under shade with the help of a silpauline sheet. Silpauline is a polythene tarpaulin which is resistant to ultraviolet radiation. A pit size of 2mX2mX0.2m is dug with spreading of plastic gunny bags to prevent the roots of nearby trees damaging the silpauline sheet. The silpauline sheet can be spread over the gunnies. An area under shade of tree with sufficient sunlight should be selected as the site for azolla production. The azolla pit can be covered with a green net or plastic net to avoid falling of tree leaves in the pit. Uniform water level should be maintained throughout the pit. About 10 kgs of sieved fertile soil is evenly spread covering the entire surface area of the silpauline sheet. A blend is made from 2kg 1-2 days old cow dung and 30 gms of super phosphate diluted in 10 litres of water and poured over the sheet. The water level is adjusted at 10 cm level by adding extra water to the pit. About 500 gms of pure culture of azolla was inoculated in to the pit. Now azolla will grow fast to fill up the pit within a period of about 10-15 days. Thereafter, about 500-600gms of azolla can be harvested daily. Azolla biomass @ 300-350 gm per square metre can be removed daily to avoid congestion and for keeping the fern at faster growing phase. A mixture of 1kg of cow dung and 20 gms of superphosphate should be added once in every week to keep the azolla in rapid growth phase. The mineral content of azolla can be improved by adding micro nutrient mixture at regular intervals. Suitable nutrients should be added to the pit as and when, nutrient shortage is noticed. About 5 kg of used soil in the pit should be replaced with fresh soil once in 30 days to avoid build up of excess nitrogen and to evade paucity of micronutrient. Substitution of 25-30 percent of water with fresh water is necessary within a interval of 10 days to prevent build up of nitrogen in the bed. After a period of six months, soil and water should be replaced with inoculation of fresh azolla. To prevent spoilage of the azolla pit due to pest and diseases, a fresh bed can be prepared with inoculation of healthy culture of azolla. In this method of production, the cost of production of azolla is about 65 paise/ kg. About 750 tonnes of azolla can be harvested from one acre area of operation. Azolla is a highly productive in nature. The biomass of azolla can be doubled in 3-10 days depending on situation and yield of up to 8 10 t /ha is recorded in rice fields of Asia region. The quantity of azolla (

Azolla pinnata) production in India was 37.8 t fresh weight/hectare (2.78 t DM/ha dry weight) (Hasan and Chakrabarti, 2009).

Chemical compositions and nutritional value of azolla

Azolla is rich in proteins, essential amino acids, vitamins (vitamin A, vitamin B_{12}, β Carotene), growth promoter mediators and minerals including calcium, phosphorous, magnesium, potassium, iron and copper. Azolla contains 4.70-6.60% dry matter; 20.45-28.54% crude protein; 11.20-15.91% crude fiber; 2.37-4.60 % ether extract; 12.30-19.91% total ash; 30.08-47.0% nitrogen free extract; 36.5-37.1 % ADF, 48.2-54.8 % NDF; 0.80-2.22 % calcium; and 0.35-1.29 % total phosphorous (Bacerra et al., 1995; Basaket al., 2002; Parthasarathy et al., 2002; Alalade and Iyayi, 2006; Indira et al., 2009; Sujatha et al., 2013; Rathod et al.,2013; Saikia et al., 2014; Acharya et al., 2015; Ashraf et al., 2015; Kavya et al., 2015; Anitha et al., 2016; Swain et al., 2015; Swain et al., 2018; Shukla et al., 2018). Besides *Azolla* is rich in iron (283.30–1569 ppm dry weight), copper (7.33 16.74 ppm dry weight) manganese (83.92–2418 ppm dry weight), zinc (46.77-325 ppm dry weight) and carotenes (206-632 ppm dry weight) (Bacerra et al.,1995; Lejune et al., 2000; Alalade and Iyayi, 2006;Mandal et al.,2012; Acharya et al., 2015;Kathirvelan et al., 2015 and Anitha et al., 2016; Querubin et al., 1986; Chatterjee et al., 2013; Srinivas et al., 2012; Saikia et al., 2014; Yadav and Chhipa, 2016; Rana et al., 2017; Gupta et al.,2018 ; Shukla *et al*., 2018). Total flavonoid and phenolic contents in methanolic extract of azolla were 56.27µg/ml and 87.35µg/ml, respectively (Mithraja et al., 2011).

Azolla as livestock feed

Exploration and sustainability of azolla production as a livestock feed has been rising due to its higher protein (19-30%) and essential amino acid contents for animal nutrition (particularly lysine) (Hasan and Chakrabarti, 2009). Azolla has huge potential as a livestock feed because it contains high amount of proteins, essential amino acids, vitamins (vitamin A, vitamin B_{12}, β-carotene), growth promoters and minerals. It has capacity to grow without inorganic nitrogen fertilization with a quicker growth rate in water without the need of reposition of the existing crops or natural environmental systems. Azolla has been exploited as a possible feed resource for pigs, ducks, chickens, cattle, fish, sheep and goats and rabbits throughout Asia and part of Africa.

Because of its easiness of farming, better yield and higher nutritive value (Lumpkin and Plucknett, 1982; Van Hove and Lopez, 1983); the use of Azolla as a feed resource for fish, swine and poultry had been practised with positive results (Castillo et al., 1981; Maurice et al., 1984; Becerra et al., 1995; Basak et al., 2002; Alalade and Iyayi, 2006; Sujatha et al., 2013). Becerraet al.(1995), Lumpkin and Plucknett (1982) and Van Hove & López (1983) opined that *Azolla* is generally a exceptional aquatic plant for livestock feed due to its ease of farming, better yield and good nutritive value. The use of Azolla as a feed for fish, swine and poultry was also suggested by Alcantara and Querubin (1985). Studies conducted by Dao and Tran (1979) recommended that one hectare of Azolla can generate 540-720 kg of protein per month. Cultivation of Azolla and its feeding to poultry can reduce feed cost, mortality rate and off smell and housefly menace in poultry shed (Mahantesh et al., 2018).

Azolla as chicken feed

Poultry, wild fowls, domesticated ducks and domestic fowl are fed azolla as an alternate feed resource in different countries (Dao & Tran, 1966). About 20% of commercial feed can be replaced by fresh *Azolla* in the diet of young chickens (Subudhi and Singh, 1978). Approximately 9 kg fresh azolla is required for 100 chickens daily, which can be obtained by culturing azolla in a pond measuring 60 m^2 area. The growth of White Leghorn female chicks given the diet with 5% azolla was better than the control group. However, the growth was slightly lower in those given the diet with 12.5% azolla. Conversely, growth rate was significantly reduced when azolla was supplemented in the diet at a level of 16 % (Singh and Subudhi, 1978).

Maize and soybean meal can be replaced by 10% dried azolla on an equal digestible protein basis in the diet of 14 day old broilers (Ali and Lesson, 1995). There was depressed growth and protein efficiency ratio with no effect on survivability at 10-20 % level of inclusion of azolla (Parthasarathy et al., 2002). The live weight, feed conversion ratio, protein and energy efficiency, dressing percentage and profitability were improved in broilers (7-42days) fed diet with 5 % azolla (Basak et al., 2002). Chick's diet formulated with addition of azolla meal (AZM) up to 10% resulted in best performance (Alalade and Iyayi, 2006). Nera brown pullets (2 weeks) were fed with 0 to 15% dried azolla which indicated that azolla could be included in the diet up to 10% for superior performance (Alalade and Iyayi, 2006). Commercial diet was offered to broilers from 2-16 weeks at 15-45%, added with fresh azolla given *ad libitum*. There was reduction in performance and slaughtering parameters and the group fed fresh azolla *ad libitum* supplementing the diet restricted at 45% exhibited optimal economic efficiency Namra et al. (2010). The performance of broilers was maintained up to a level of inclusion of 7.5% dried azolla in their diet (Prabina and Kumar, 2010). Addition of 4.5% azolla in the diet of broilers resulted in reduced cholesterol content in serum and meat without any adverse effect on production performance (Balaji et al., 2009; Balaji et al., 2010). Supplementation of dried azolla up to 5 % by replacing soybean meal had no undesirable effect on palatability, efficiency of feed utilization and carcass quality of broilers (6 week of age) and was profitable (Dhumal et al., 2009). Cobb broilers (1-42d) were fed diet included with 0-15% azolla in powder form in corn-soybean meal diet. Addition of 5 % azolla resulted in lowest feed intake, highest weight gain and best feed conversion ratio (Naghshi et al.,2014). The carcass efficiency percentage was

significantly higher in broilers belonging to azolla dietary group. The group fed 5 % azolla had the least feed cost per kg body weight. Supplementation of azolla in the diet of broilers more than 5% depresses nutrient utilization and performance (Parthasarathy et al., 2002; Basak et al., 2002). Safe level of inclusion of azolla is up to 10% in pullet chicks (Alalade et al., 2007). Commercial diet can be replaced by fresh azolla at a level of 20% or more (Subudhi and Singh, 1978; Namra et al., 2010). Inclusion of dried azolla at a level of 15% in the diet of commercial layers in a 16 week study could not affect the performance of the laying hens in terms of egg production (Khatun et al., 2008). Vanaraja laying hens fed diets incorporated with 10 % azolla meal during a period of 8 weeks did not show any adverse effect egg production and egg quality (Boitai et al., 2018). Elevated levels of ADF and lignin have been indicated as the major factor restricting the proper utilization of azolla meal (AZM) by monogastric animals (Bukingham et al., 1978; Tamany et al., 1992). There are contradictory reports regarding the feed consumption in poultry fed on azolla incorporated diets. Feed intake was significantly affected in chicks fed on 10 and 15 % AZM diets (Cambel, 1984; Bhuyan et al., 1998). The feed consumption of broilers was not affected due to supplementation of azolla meal in the diet (Castillo,1983; Basak et al.,2002). However, it was clarified that the decrease in dry matter intake might be due to reduction in intake of bulky AZM based diets by the birds (Bacerra et al. (1995). The feed intake was considerably low in laying ducks (153 g/duck) with azolla supplementation (200g fresh azolla/duck/day) as against control group (219 g/duck) (Sujatha et al.2013). Feeding of 30 % (w/w) azolla along with 70 % commercial broiler feed increased body weight gain, improved the FCR, reduced the mortality rate due to heat stress during summer and reduced the cost of production of broiler (Mahanthesh et al., 2018). Supplementation of azolla in powder form to chicken feed significantly improved the carotene content of the eggs (Ali and Leeson,1995). Kannaiyan and Kumar (2005) observed better egg production in laying hens fed fresh azolla @100g/bird/day. Similarly, supplementation of fresh azolla@200g/bird/day by replacing sesame oil in the diet of laying hens improved the egg production and feed conversion ratio (Khatun et al., 1999). Azolla feeding had positive effect on egg shell strength because of its high calcium content as egg shell consists of minerals especially calcium carbonate that deposits in organic matrix (Austic and Nesheim,1990). The antibody titre against ranikhet virus was higher in broilers fed 10 % dried azolla compared to those received 7.5 % of dried azolla feed (Prabina and Kumar,2010). The cellular immune responses was higher in birds fed diet supplemented with azolla meal at levels of 5-10% (Mishra et al.,2016). Besides, Azolla improves carcass traits at processing (Abd El-Ghany, 2020). Broilers fed 5 % azolla meal had significantly ($P<0.05$) higher overall acceptability of cooked meat, breast meat yield and cooking yield. However, there were no significant differences in proximate composition of broiler meat of control group and the azolla meal fed group (Rana et al., 2020).

Azolla as duck feed

There was no improvement in egg production and the yolk color was darker in Mallard ducks by replacing rice grain-snail-shrimp diet partially (20%) (Alcjar and Aragones (1989). Feeding of fresh azolla was detrimental to growth performance in native ducks when fed fresh azolla + 40 or 60% of chicken grower mash (Gavina,1994). Whole soybeans can be partially replaced by fresh azolla up to a level of 20% of the total crude protein in diets of meat type ducks based on sugar cane juice with no undesirable effect on growth rate or health with lowest feed cost per kg weight gain and highest net profit per bird. However, at higher level of replacement than the above, there was poor growth rate and feed conversion efficiency (Bacerra et al., 1995). Supplementation of fresh azolla to a formulated feed in duckling (2-8 weeks) exhibited higher growth rate (Liu Xiang et al.,1998). The performance was not adversely affected in indigenous layer ducks by replacing 0-20% commercial layer feed with 200g fresh azolla per duck per day with daily saving of approximately Rs. 1/- per duck, increase in Roche fan colour score and yolk colour score (6.0 vs 7.4), which may be due to the enrichment of azolla with β-carotene pigment (Sujatha et al.,2013).

There was no significant difference among the various dietary treatments containing 0, 20, 30 and 40% azolla replacing matching levels of paddy rice-snail-shrimp (PSS), both in Mallard ducks for egg production and Muscovy ducks for meat production in terms of production efficiency (Escobin,1987). A backyard duck farm with a capacity of 50 ducks will need about 10 kg of fresh azolla per day (200g fresh azolla/duck) to substitute 30 percent of commercial feed (Sujatha et al.,2013). Azolla cultivation in a shallow pond of dimension 68 m^2 or 17 superficial tanks each of 4 m^2 with 30 cm in deepness will produce sufficient azolla daily to meet the daily requirement of 50 ducks. Approximately Rs50/- can be saved on feed cost daily. A water body can be constructed under the shade of the tree with the aid of a silpauline sheet which is highly suitable for island geographical condition. The Roche fan colour score was improved with inclusion of azolla in the diet. The yolk colour score of 6.0 recorded in the eggs of control group ducks which was increased to 7.4 when azolla was included in the diet. The pigmenting ability of azolla clearly established by its high Roche fan colour score which might be due to the presence of more quantity of β-carotene pigment in azolla. Bastian (1987) observed a change in yolk colour due to azolla supplementation of diet. Feeding of fresh Azolla at levels of 75 or 250 g/duck/day deteriorated the feed conversion ratio in Mallard ducks (Lawas et al., 1998).

Conclusions

Azolla has been a very popular source of green feed because of its high nutritional value in terms of protein, essential amino acids, vitamins and minerals; good potential for imparting rich colour to egg yolk due to presence of β-carotene pigment; ease of cultivation and high productivity in spite of land constraint situation faced by the farmer. Azolla supplementation in chicken feed reduces mortality due to heat stress during summer. It also reduces off smell, house fly population and mosquito menace in poultry house. Azolla production through low cost technology can be popularised and supplemented in the diets of chicken and ducks either in fresh or dried form for economic production of meat and egg.

References

References are available on request from corresponding author.