***Original Research Article***

**Effect of Supplementation of Azolla meal *(Azolla pinnata)* and fish meal on dry matter intake and water intake of Konkan Kanyal goat**

abstract

**Aims**:  Azolla meal and fish meal are rich sources of protein and essential nutrients that can contribute to a well-balanced diet for male goats. Studying the optimal levels of these ingredients in the diet can help to ensure that, the goats receive all the nutrients they need for growth, development and overall health. Nutritional advantages of supplementation of Azolla meal and fish meal to Konkan Kanyal goat were exploited in the present study by feeding Azolla meal and fish meal through concentrate along with basal feed. This work aimed to facilitate supplementation of Azolla meal and fish meal not only increases dry matter intake but also improved the water intake.

**Study design**: This research was experimental and performed in a field.

**Place and Duration of Study**: This study was conducted at Instructional Livestock farm, Department of Animal Husbandry and Dairy Science, College of agriculture, Dr. BSKKV, Dapoli, Maharashtra, India, during 2023-24

**Methodolgy:** The concentrate feed was prepared by supplementation of Azolla meal and fish meal with basal feed (Hybrid napier grass + Red gram straw + concentrate) with supplementation of 4 gm fish meal (A0F1), 8 gm fish meal (A0F2), 4 gm Azolla meal (A1F0), 4 gm Azolla meal and 4 gm fish meal (A1F1), 4 gm Azolla meal and 8 gm fish meal (A1F2), 8 gm Azolla meal (A2F0), 8 gm Azolla meal and 4 gm fish meal (A2F1) and 8 gm Azolla meal and 8 gm fish meal (A2F2) in concentrate, respectively and the dry matter intake and water intake of experimental goats were recorded. Research Conducted with three Replications.

**Results:** Most optimum level of treatment combination of 4 gm Azolla meal and 8 gm fish meal (A1F2) supplementation through concentrate feed was found in obtaining maximum dry matter intake while treatment combination of 8 gm Azolla meal and 8 gm fish meal (A2F2) supplementation through concentrate feed was found in obtaining maximum water intake.

**Conclusion:** The study concludes that supplementing upto 4 gm Azolla meal and 8 gm fish meal (A1F2) through concentrate to experimental goats increases the dry matter intake while supplementation upto 8 gm Azolla meal and 8 gm fish meal (A2F2) through concentrate to experimental goats increases the water intake.

*Keywords: Azolla meal, Fish meal, Dry matter intake, Water intake, Konkan Kanyal goat*

1. INTRODUCTION

India basically is an agricultural country and livestock is the backbone of agriculture. Livestock sector has been playing an important role in Indian economy and is an important sub-sector of Indian agriculture (Taneja, 2014). The trend of incorporating feed supplements into goat diets has gained popularity due to several factors driven by economic, nutritional and sustainability considerations. Supplements such as mineral mixes, vitamins and protein-rich meals (e.g., soybean meal, fish meal) are common.

 Azolla meal and fish meal are rich sources of protein and essential nutrients that can contribute to a well-balanced diet for male goats. Fish meal is an excellent source of high-quality protein, typically ranging from 60 % to 72 % of its dry weight. Traditionally used as livestock feed supplement (IS: 4307 – 1983). Researching the effectiveness of incorporating these ingredients can help goat farmers to make uniformed decisions about their feeding strategies. The diet of male goats directly impacts their health, growth rate and overall performance. By studying the effects of Azolla meal and fish meal in their diet, researchers can assess how these ingredients influence parameters such as weight gain, energy levels and overall health status of the goats. Balancing nutrients in diets by using the minimum amount of fish meal to meet the specific amino acid requirements for fast growth and reproduction and reducing feed cost constitute and aimed to increase dietary nutrient density and digestibility of feed to increase biological performance. Incorporating alternative protein sources like Azolla meal can contribute to sustainable farming practices by reducing the reliance on conventional feed sources. Understanding the impact of these ingredients on male goat diets can help to promote sustainable agriculture practices within the livestock industry. Studying the incorporation of Azolla meal and fish meal in the diet of male goats becomes essential to ensure optimal nutrition, cost-effective feeding strategies, improved health and performance of the goats and the promotion of sustainable livestock farming practices.

Thus, keeping the foregoing in mind, the current investigation has been presented to ascertain the ideal level of Azolla meal and fish meal inclusion as a feed supplement.

2. material and methods

**Location and period of study**

The present work was carried out at the Instructional Livestock Farm, Department of Animal Husbandry and Dairy Science, College of Agriculture, Dapoli (DR. BSKKV DAPOLI)- 415 712, Ratnagiri, Maharashtra, India during 2023- 2024.

**2.1 Material:**

Hot air oven, Muffle furnace, Desiccator, Kjeldahl unit, Distillation assembly, Titration unit, Hot plate, Soxhlet apparatus, Beaker, measuring cylinder, pipette, conical flasks, crucibles, Metal tongs, Kjeldahl flask, Lipless beakers, Funnels, Filter papers, Whatman’s papers, Feeders, Water buckets, Nylon rope, Ear tags, Broom, Chaff cutter, Weighing balance, Metabolic cages, Measuring tape and labels.

**2.2 Methodology**

**2.2.1. Preparation of Azolla meal and fish meal**

A growth trial of 90 days was conducted on Twenty-seven Konkan Kanyal goats divided in nine treatment combination groups of three goats in each to study the effect of feeding optimum level of Azolla meal and fish meal on growth performance and chevon quality of goats. Dried fish meal procured from market was again dried in the solar tunnel dryer for removal of moisture present in the fish meal (till DM 95 per cent). Fresh Azolla was grown at instructional dairy farm ponds. Fully grown Azolla was harvested and dried inside the solar tunnel dryer for making the Azolla meal.

**2.2.2. Feeding**

 All the experimental goats including control group (A0F0) were fed as per ICAR (2013) feeding standard to meet their nutritional requirement. The Azolla meal and fish meal were supplemented through concentrate to goats in treatment combinations *viz;* (A0F1) 4 gm fish meal, (A0F2) 8 gm fish meal, (A1F0) 4 gm Azolla meal, (A1F1) 4 gm Azolla meal and 4 gm fish meal, (A1F2) 4 gm Azolla meal and 8 gm fish meal, (A2F0) 8 gm Azolla meal, (A2F1) 8 gm Azolla meal and 4 gm fish meal and (A2F2) 8 gm Azolla meal 8 gm fish meal supplemented with concentrate per day up to the 90 days with seven days of metabolic trial for collection of urine and faeces samples of goats.

**2.2.3. Treatment details**

Number of treatment combinations: 9

No. of replications: 3

Total no. of animals: 27

**2.2.4. Experimental layout:**

Basal feed :- Red gram straw +Hybrid Napier grass +Concentrate mixture

F1 = 4 gm fish meal

A1 = 4 gm Azolla meal

F2 = 8 gm fish meal

A2 = 8 gm Azolla meal

**Treatment combinations:**

A0F0 - Basal feed (Control)

A0F1- Basal feed + 4 gm fish meal

A0F2- Basal feed + 8 gm fish meal

A1F0- Basal feed + 4 gm Azolla meal

A1F1- Basal feed + 4 gm Azolla meal + 4 gm fish meal

A1F2- Basal feed + 4 gm Azolla meal+ 8 gm fish meal

A2F0- Basal feed + 8 gm Azolla meal

A2F1- Basal feed + 8 gm Azolla meal + 4 gm fish meal

A2F2- Basal feed + 8 gm Azolla meal + 8 gm fish meal

**2.2.4.Replications**

The research was conducted with Three replications.

**3.RESULTS AND DISCUSSION**

**3.1 Dry matter intake**

The average dry matter intake was recorded in experimental period illustrated in Table 1 and graphically depicted in Fig.1

The data pertaining of table 1 indicated that, among different treatment combinations, lowest dry matter intake was observed in treatment combination A0F0 (454.85 g/day) whereas highest dry matter intake was found in treatment combination A1F2 (477.14 g/day), respectively.

From the evident of Table 1 it is observed that, when concentrate was constant and levels of fish meal were varying there was increase in dry matter intake by experimental goats and it were recorded as 477.14, 475.02, 467.46, 465.76 g/day for treatment combinations A1F2,A1F1, A0F2, A0F1, A2F2, A2F1, respectively whereas it was observed that, levels of Azolla meal was varying there was decrease in dry matter intake by experimental goats and it were recorded as 463.13, 461.94, 459.21, 457.81 g/day for treatment combinations A2F2, A2F1, A1F0, A2F0, respectively. Whereas no supplementation of Azolla meal or fish meal through concentrate it was observed that there was decrease in dry matter intake and it was 454.85 g/day (% DM) for treatment combination A0F0 was observed in experimental goats.

**Table 1 : Effect of supplementation of Azolla meal and fish meal on average dry matter**

 **intake by experimental goats (% DM)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment combination** | **Average daily dry matter intake (g/day)** | **Average body weight (kg)** | **DMI per 100 kg body weight** |
| **A0F0** | 454.85d | 13.68d | 4.55d |
| **A0F1** | 465.76b | 15.49a | 4.66b |
| **A0F2** | 467.46b | 15.42a | 4.67b |
| **A1F0** | 459.21cd | 14.49c | 4.59cd |
| **A1F1** | 475.02a | 15.46a | 4.75a |
| **A1F2** | 477.14a | 15.61a | 4.77a |
| **A2F0** | 457.81cd | 14.42bc | 4.58cd |
| **A2F1** | 461.94c | 14.59b | 4.62c |
| **A2F2** | 463.13bc | 14.89b | 4.63c |
| **S.E.M (A)** | 1.03 | 0.12 | 0.01 |
| **S.E.M (F)** | 1.03 | 0.12 | 0.01 |
| **S.E.M (A x F)** | 1.79 | 0.20 | 0.02 |
| **C.D (A)** | 3.10 | 0.35 | 0.03 |
| **C.D (F)** | 3.10 | 0.35 | 0.03 |
| **C.D (A x F)** | 5.37 | 0.61 | 0.05 |
| **Result (Tr. SS)** | SIG | SIG | SIG |
| **Result (A)** | SIG | SIG | SIG |
| **Result (F)** | SIG | SIG | SIG |
| **Result (A x F)** | SIG | SIG | SIG |

Statistically, interpretation of data indicated that results are statistically significant for both the factors under study i.e. fish meal and Azolla meal at (P<0.05) level of significance. Similarly, interaction effect between two factors under study is also statistically significant.

The results presented in table 1 indicated that, dry matter content of concentrate was 88.10 per cent and that of dry matter content of fish meal was 94.00 per cent so as level of fish meal supplementation increases it shows increase in dry matter content in concentrate whereas dry matter content of Azolla meal was 87.00 per cent and that of supplementation of Azolla meal through concentrate it was slight increase in dry matter content as compared with no supplementation of Azolla meal and fish meal through concentrate feeding to experimental goats.

The present results are also correlated to the findings given by Wadhwani et al. (2010) who studied on the performance of growing sheep on Azolla based diet. Marwari, Patanwadi and Merino X Patanwadi weaner lambs were fed with *viz;* T1 : TMR I-Conventional group (Maize- 22 per cent, Ground nut cake- 15 per cent, Rice polish- 15 per cent, molasses- 10 per cent, mineral mixture- 3 per cent and urea treated wheat straw- 35 per cent), T2 : TMR-II supplemented non- conventional group I (Azolla- 10 per cent, P J Pods -15 per cent, Corn steep liquor -12 per cent, Rice Polish- 10 per cent, Groundnut Cake- 5 per cent, molasses- 10 per cent, mineral mixture- 3 per cent and urea treated wheat straw- 35 per cent) and T3 : TMR-III supplemented non-conventional group II (Azolla-20 per cent, P J Pods -17 per cent, Corn steep liquor -15 per cent, molasses- 10 per cent, mineral mixture- 3 per cent and urea treated wheat straw- 35 per cent). The total dry matter intake during the entire experimental period was recorded to be 85.37 ± 19.10, 90.86 ± 4.30 and 81.02 ±6.09 kg/head for T1, T2 and T3, respectively and concluded that, DM intake per kg gain was higher in non-conventional group (P<0.05).

These present results in respect of dry matter intake are found competitive with earlier reports of Ghodake et al. (2012) revealed that, the dry matter intake in Osmanabadi kids and fed with concentrate replaced with different levels of Azolla meal with the treatment T1 (control), T2 (15 per cent concentrate was replaced with Azolla meal, T3 (25 per cent concentrate was replaced with Azolla meal) and found that, the average daily DM intake was significantly more in T2 (0.35 kg) followed by T1 (0.34 kg) and comparatively less in T3 (0.33 kg) and concluded that, Azolla meal feeding was effective up to 15 per cent in concentrate mixture.

The present results are correlated with the findings reported by Agare et al. (2015) on effect of different creep feeds on the growth performance of Konkan Kanyal kids and recorded the dry matter intake values as 641.13± 1.57, 645.40±0.69, 656.09±0.86, 645.75±1.71 g/kids for the treatments T0,T1,T2, and T3, respectively and concluded that, higher dry matter intake was observed in treatment T2 (20 per cent) creep feed replaced with Azolla meal by Konkan Kanyal kids. On basis of earlier reports, present results are in agreement with the findings reported by Kumar et al. (2015) who studied on the effect of Azolla based complete pellet feed on growth, nutrient utilization, blood metabolites and rumen fermentation in Barbari goats and revealed that, the replacement of conventional concentrate mixture with sun-dried Azolla meal has no adverse effect on palatability of pellet.

These results are found compatible with the results determined by Ahmed et al. (2016) studied performance of growing sheep on Azolla based diet for treatments *viz;* T1, T2, T3, T4 and T5 and fed on measured quantity of concentrate mixture containing 0, 6, 12, 18 and 24 per cent Azolla replaced with 0, 25, 50, 75 and 100 per cent linseed cake, respectively and observed the performance of growing sheep on Azolla based diet and recorded the dry matter intake as 0.790±0.02, 0.786±3.10, 0.785±0.05, 0.783±0.04, 0.719±0.08 kg/day for treatments T1, T2, T3, T4 and T5, respectively and concluded that, 50 per cent linseed cake replaced with concentrate mixture containing 6 per cent Azolla in the sheep diet performed best than other treatments.

The present investigation is found compatible with results determined by Dongare et al. (2019) on replacement of concentrate mixture with fresh Azolla (*Azolla pinnata*) on milk production and quality in Konkan Kanyal goat. Konkan Kanyal goats were fed with treatmentssuch as T1 - Basal feed (Guinea grass + Tree leaves + Paddy straw) + 400 gm conc. T2 - Basal feed + 300 gm conc. + 100 gm fresh Azolla, T3 - Basal fed + 200 gm conc. + 200 gm fresh Azolla, T4 - Basal feed + 100 gm conc. + 300 gm fresh Azolla and T5 - Basal feed + 400 gm fresh Azolla and reported the results as the dry matter intake of animals fed with the treatment T4 (1119.10 g/day) was significantly higher than the other treatment groups.

Toradmal et al. (2020) revealed the results on supplementation of green Azolla (*Azolla pinnata*) on growth performance of Osmanabadi goat kids and reported that, daily dry matter intake per 100 kg body weight of the treatment group T1, T2, T3 and T4 were 4.00, 4.02, 4.05 and 4.12 kg, respectively. The daily dry matter intake through roughages and concentrate with green Azolla was affected significantly (P<0.05). The dry matter intake per 100 kg body weight was noticed more in T4 treatment followed by T3, T2 and T1 and concluded that, influence of incorporation of green Azolla and concentrate mixture improves the dry matter intake of the experimental goats and also reported that, dry matter intake of experimental goats as 800.99, 881.56, 987.33, 1119.10, 902.53 g/goat for the treatments T1, T2, T3, T4 and T5, respectively and concluded that, treatment T3 (1119.10 g/goat) had the highest dry matter intake among all treatments. The present results are also correlated to the findings reported by Kumari et al. (2021) on effect of different levels of Azolla meal on nutrient utilization and growth performance in Black Bengal kids fed with treatments T1, T2 and T3 having graded levels of Azolla meal (0, 20 and 40 per cent) mixed with concentrate mixture and green fodder berseem and results showed that, dry matter intake as 458.12±0.05, 449.54±0.29, 494.66±0.13 g/day for the treatments T1, T2 and T3, respectively and reported that, highest dry matter intake of kids was 40 per cent level of Azolla meal (T3) than the other treatment groups. The total DMI of T1, T2 and T3 group were 458.12, 449.54 and 494.66 g/day, respectively. These results are correlated with recent investigation by Dev et al. (2022) observed the performance of growing Sirohi goats on Azolla (*Azolla pinnata*) based diet and reported the findings for dry matter intake of Sirohi goats as 0.98±0.08 and 1.00±0.09 kg/day and concluded that, there was no significant difference in voluntary feed intake and body weight among the treatment and control groups overall or in any of the weeks during the experiment.

**3.1.1 Effect of supplementation of fish meal on average dry matter intake by experimental goats (% DM)**

The average daily dry matter intake was recorded in experimental period illustrated in Table 1 and graphically depicted in Fig.1.

From critical perusal of table 1 indicated that, among different treatment combinations, lowest dry matter intake was observed in A0F0 (454.85 g/day) whereas, highest dry matter intake was found in treatment combination A1F2 (477.14 g /day), respectively.

These present findings in respect of dry matter intake are found competitive with earlier reports of Huq et al. (1996) who studied on growth and feed utilization in Black Bengal goats on road side grass-based diet supplemented with fish meal and Urea Molasses Block (UMB) and concluded that, fish meal fed without Urea Molasses Block (UMB) had the highest dry matter intake by goats. These present results are also correlated to that the findings reported by Atti et al. (2007) on the effect of fish meal in lamb diets on growth performance, carcass characteristics and subcutaneous fatty acid composition with the 5 per cent and 10 per cent fish meal in concentrate of lamb diets and recorded the results with respect to dry matter intake as for 5 per cent fish meal in concentrate for 55 days and 105 days as 0.9 and 0.9 g/day, respectively whereas, for 10 per cent fish meal in concentrate for 55 days and 105 days as 1.1 and 1.0 g/day, respectively and revealed the effects of fish meal content in concentrate for lamb diets and concluded that, dry matter intake and average daily gain were not affected (P>0.05) by fish meal feeding.

**3.2 Effect of supplementation of Azolla meal and fish meal on average water intake of experimental goats (lit/day)**

The average water intake was recorded in experimental period illustrated in Table 2 and graphically depicted in Fig.2

The data showed in table 2 indicated that among different treatment combinations, lowest water intake was recorded in A0F0 (0.53 lit/day) whereas, highest water intake was found in treatment combination A1F2 (0.64 lit/day), respectively.

From the evident of Table 2 it is observed that, when concentrate was constant and levels of fish meal were varying there was significant increase in water intake by experimental goats and it were recorded as 0.65, 0.64, 0.59, 0.58, 0.58, 0.56, 0.56, 0.55 and 0.53 lit/day for treatment combinations A2F2,A1F2,A1F1, A0F2, A0F1, A2F1, A2F0, A1F0, A0F0, respectively whereas it was observed that, levels of Azolla meal supplemented through concentrate was varying there was increase in water intake in experimental goats but it was comparatively least than goats fed with fish meal through concentrate which was observed due to salt content was increased by supplementing the levels of fish meal through concentrate whereas no supplementation of Azolla meal or fish meal through concentrate recorded the lower water intake (0.53 lit/day) as compared to other treatment combinations fed to experimental goats.

**Table 2: Effect of supplementation of Azolla meal and fish meal on average water intake of experimental goats (lit/day)**

|  |  |
| --- | --- |
| **Treatment combination** | **Water intake (lit/day)** |
| **A0F0** | 0.53c |
| **A0F1** | 0.58b |
| **A0F2** | 0.58b |
| **A1F0** | 0.55bc |
| **A1F1** | 0.59b |
| **A1F2** | 0.64a |
| **A2F0** | 0.56bc |
| **A2F1** | 0.56bc |
| **A2F2** | 0.65a |
| **S.E.M (A)** | 0.0068 |
| **S.E.M (F)** | 0.0068 |
| **S.E.M (A x F)** | 0.0118 |
| **C.D (A)** | 0.0205 |
| **C.D (F)** | 0.0205 |
| **C.D (A x F)** | 0.0355 |
| **Result (Tr. SS)** | SIG |
| **Result (A)** | SIG |
| **Result (F)** | SIG |
| **Result (A x F)** | SIG |

The statistical interpretation of data indicated that, results are statistically significant for both the factors under study i.e. fish meal and Azolla meal at (P<0.05) level of significance. Similarly, interaction effect between two factors under study are also statistically significant. These results are also correlated to the findings reported by Wadhwani et al. (2015) studied the performance of growing sheep on Azolla based diet and recorded the total water intake during the entire experimental period were recorded as 3154.46±327.20, 2735.92±139.54 and 2454.62±161.66 (ml/day) for T1, T2 and T3, respectively.

The results of present investigation are found compatible with results of Toradmal et al. (2017) conducted a trial on supplementation of green Azolla on growth performance of Osmanabadi goat kids and revealed the water intake/day/goat (lit) were found as 0.750 lit for T1 (Soybean straw +Concentrate), 0.830 lit for T2 (basal diet+100 gram green Azolla), 0.870 lit, T3 (basal diet+200 gram green Azolla) and 0.970 lit for T4 (basal diet+300 gram green Azolla) group.

The present results are also correlated to the findings of Bello et al. (2018) who observed the water consumption rate of Konkan Kanyal goats fed finger millet straw supplemented with T1-0, T2 -20, T3- 40, T4- 60 and T5-80 per cent levels of dried poultry droppings-based diets and water intake reported as 1.4, 2.2, 3.5, 2.7 and 1.7 lit. of water/day for optimum utilization of the feed.

On the basis of earlier findings with respect to water intake the results reported by Dongare et al. (2019) on the replacement of concentrate mixture with fresh Azolla (*Azolla pinnata*) on milk production and quality in Konkan Kanyal goats fed with treatments *viz*, T1 - Basal feed (Guinea grass + Tree leaves + Paddy straw) + 400 gm conc. T2 - Basal feed + 300 gm conc. + 100 gm fresh Azolla, T3 - Basal fed + 200 gm conc. + 200 gm fresh Azolla, T4 - Basal feed + 100 gm conc. + 300 gm fresh Azolla and T5 - Basal feed + 400 gm fresh Azolla, respectively and recorded the observations as T1 (1.20), T1 (1.19) , T1 (1.24), T1 (1.32) , T1 (1.22) lit/goat and concluded that, there is no significant difference was observed with respect to water intake among the treatments.

The present findings are compatible with the results reported by Kokani et al. (2023) conducted a trial on effect of feeding hydroponic horse gram sprouts on growth performance of Konkan Kanyal goats fed with treatments *viz;* T1 (0 per cent), T2 (15 per cent), T3 (30 per cent), T4 (45 per cent) levels for hydroponic horse gram sprouts where T1 (100 per cent), T2 (85 per cent), T3 (70 per cent), T4 (55 per cent) levels for basal feed and revealed that, water intake/day/goat (lit.) were found as 0.65 lit. for T1 (finger millet straw+ mulato grass), 0.56 lit. for T2 (Basal diet+15 per cent sprouted horse gram), 0.55 lit. for T3 (Basal diet+30 per cent sprouted horse gram) and 0.57 lit. for T4 (Basal diet+45 per cent sprouted horse gram) group.

The results determined by the recent investigation with respect to water intake by Gavit et al. (2022) investigated on nutritional benefit and economic value of feeding fenugreek seed as natural feed additives on growth performance on Konkan Kanyal kids and observed that, 904.33 ml water intake (ml/goat) for treatment group T0, 911.66 ml for treatment group T1, 913.66 ml for treatment group T2, 920.33 ml for treatment group T3, 925.66 ml for treatment group T4 and 930.33 ml for treatment group T5, respectively and concluded that, highest water intake by animals in the treatment group T4 (930.33 ml/goat).

 On basis of recent investigation with respect to water intake by Kore (2023) observed the effect of feeding Spirulina *(Spirulina plantensis)* on growth performance of Konkan Kanyal kids and recorded the water intake (ml/day/goat) as 1091.33, 1110.2, 1142.28 and 1152.37 for the treatments T1 (Basal diet without spirulina), T2 (Basal diet + 1.0 g spirulina in 10 ml of water), T3 (Basal diet + 1.5 g spirulina in 15 ml of water), and T4 (Basal diet + 2.0 g spirulina in 20 ml of water), respectively and concluded that, T4 (1152.37 ml/day/goat) had a significantly higher water intake than other treatments.

**4. CONCLUSION**

The study concludes that supplementation of 4 gm Azolla meal and 8 gm fish meal through concentrate feed to Konkan Kanyal goats can improve its dry matter intake, which helps in overall growth and development of animals while it could be results that, 8 gm Azolla meal and 8 gm fish meal increases the water intake of animals. Hence Supplementation of Azolla meal and fish meal could be a use for adoption of the sustainable goat production.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that No generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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