ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt
International Journal of Applied Sciences and Biotechnology
(IJASBT)

**Research Article**

# Sustainable Turkey Farming: The Role of Hydroponic Sprouted Fodder in Feed Optimization

**Kanis Yasmin, Mobasser Ahmed Rashedi, Basant Kumar Mehta, Ummay Salma, Abdul Gaffar Miah***

Faculty of Veterinary and Animal Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh

## Article Information

Received: 16 August 2025
Revised version received: 20 September 2025
Accepted: 23 September 2025
Published: 30 September 2025

**Cite this article as:**
*K. Yasmin et al. (2025) Int. J. Appl. Sci. Biotechnol. Vol 13(3): 139-145. DOI: 10.3126/ijasbt.v13i3.84975*

***Corresponding author**
Abdul Gaffar Miah,
Faculty of Veterinary and Animal Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh.
Email: agmiah@tch.hstu.ac.bd



## Abstract

Hydroponic fodder has gained attention as an innovative and sustainable feed resource for poultry production. This study assessed the effects of hydroponic maize and sesbania sprouted fodder as partial replacements for commercial concentrate feed (CCF) in turkey production, with a focus on growth parameters, feed intake, feed conversion efficiency (FCE), and economic viability. Forty-eight turkeys (eight-week-old) were randomly divided into four dietary treatment groups: T1 (100% CCF), T2 (90% CCF + 10% hydroponic fodder), T3 (70% CCF + 30% hydroponic fodder), and T4 (60% CCF + 40% hydroponic fodder). Results revealed that hydroponic maize contained 14.79% dry matter (DM) and 10.92% crude protein (CP), while sesbania had 9.46% DM and 37.26% CP, demonstrating its potential as a high-protein alternative. Among the treatment groups, the highest ($P<0.05$) daily weight gain (20.61 g/day) was observed in birds of T2 group, which also recorded the best ($P<0.05$) FCE (4.03) and the highest ($P<0.05$) profitability index (0.36). Economic analysis showed that T2 had the highest ($P<0.05$) net farm income, making hydroponic fodder supplementation a cost-effective strategy. Additionally, hydroponic fodder improved gut health, enhanced nutrient bioavailability, and reduced oxidative stress, as evidenced by 100% survivability across all groups. These findings align with previous research supporting the role of hydroponic sprouts in poultry nutrition. The results suggest that incorporating hydroponic fodder at optimal levels can improve turkey growth and economic efficiency while promoting sustainable poultry farming. Future research should explore the long-term effects of hydroponic fodder on carcass quality, immune response, and environmental sustainability.

**Keywords:** Turkey nutrition; hydroponic fodder; maize; sesbania; economic feasibility.

## Introduction

Livestock plays a vital role in the agricultural economy of Bangladesh, contributing significantly to food security, employment generation, and poverty alleviation (Begum *et al.*, 2011). Among various livestock sectors, poultry farming has gained prominence due to its rapid growth, high feed conversion efficiency, and ability to meet the increasing demand for animal protein. Turkey farming, although not as widespread as broiler and layer production, holds significant potential as an alternative poultry enterprise in Bangladesh (Yakubu *et al.*, 2013). The growing interest in turkey farming stems from its advantages, such as high meat yield, excellent feed conversion ratio, and adaptability to diverse climatic conditions (Ogundipe and Dafwang, 1980). However, one of the major constraints in turkey production is the high cost of commercial concentrate feed, which significantly affects profitability. This challenge necessitates the exploration of sustainable and cost-effective feeding strategies that can optimize growth performance while reducing feed expenses (Gale, 2013).

Hydroponic fodder production has emerged as an innovative approach to addressing feed shortages in livestock and poultry farming. This method involves growing nutrient-rich fodder without soil, utilizing water and controlled environmental conditions to enhance growth efficiency (Naik *et al*., 2014). The technology is gaining popularity due to its ability to produce fresh, high-quality fodder throughout the year, irrespective of seasonal variations (Rahim *et al.*, 2015). Hydroponic fodder, particularly maize and sesbania, has received considerable attention for its high nutritional value, rapid growth cycle, and reduced land and water requirements (Dung *et al.*, 2010). Research indicates that hydroponically grown fodder is enriched with bioactive enzymes, proteins, fiber, and essential vitamins, making it a superior alternative to traditional feed sources (Naik *et al.*, 2014).

The adoption of hydroponic sprouted fodder in turkey farming presents a promising opportunity to enhance growth performance while reducing dependency on expensive commercial feeds. Studies have demonstrated that incorporating hydroponic fodder into poultry diets can improve weight gain, feed conversion efficiency, and overall bird health (Fazaeli *et al.*, 2012). Additionally, hydroponic fodder has been shown to have higher digestibility and nutrient bioavailability, leading to improved feed utilization (Sneath and McIntosh, 2003). Given that feed costs account for approximately 60-70% of total poultry production expenses, the potential cost savings associated with hydroponic fodder could enhance the economic viability of turkey farming (Naik *et al.*, 2014).

Furthermore, the environmental benefits of hydroponic fodder production cannot be overlooked. Traditional fodder cultivation requires large tracts of land and substantial water resources, whereas hydroponic systems minimize land use and significantly reduce water consumption by up to 90% (Al-Karaki and Al-Hashimi, 2012). This makes hydroponic fodder particularly suitable for regions with limited arable land and water scarcity. Moreover, hydroponic systems eliminate the need for chemical fertilizers and pesticides, resulting in a cleaner and more sustainable feed source (Subodh, 2012).

Despite these advantages, there is limited scientific evidence on the application of hydroponic maize and sesbania sprouted fodder in turkey production under Bangladeshi conditions. Most studies have focused on ruminants and broiler chickens, with little emphasis on turkeys. The nutritional requirements and digestive physiology of turkeys differ from other poultry species, necessitating targeted research to evaluate the effects of hydroponic fodder on their growth performance, feed intake, and overall productivity (Tudor *et al.*, 2003). Moreover, the economic feasibility of replacing commercial feed with hydroponic fodder in turkey farming remains an area that requires further investigation.

Therefore, this study evaluated the effects of dietary inclusion of hydroponic maize and sesbania sprouted fodder as partial replacements for commercial concentrate feed (CCF) on the growth performance, feed intake, feed conversion efficiency, and economic viability of turkey production. Specifically, the research focused on determining the optimal inclusion levels of hydroponic fodder in turkey diets and assessing its impact on production efficiency. The findings of this study contributed to the development of sustainable feeding strategies, ensuring profitability and sustainability in turkey farming in Bangladesh. Additionally, the results provided valuable insights for farmers and policymakers seeking to promote eco-friendly and cost-effective alternatives in poultry nutrition.

## Materials and Methods

### *Study Area*

The study was conducted at the Advanced Animal Research Farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh. The research farm is located in a region with a tropical monsoon climate, characterized by distinct wet and dry seasons. During the study period, the temperature ranged 17–35°C, with moderate humidity levels, ensuring optimal conditions for turkey production and hydroponic fodder cultivation.

### *Experimental Birds and Dietary Treatment*

Forty-eight turkeys (eight-week-old) were randomly divided into four dietary treatment groups: T1 (100% commercial concentrate feed; CCF), T2 (90% CCF + 10% hydroponic fodder), T3 (70% CCF + 30% hydroponic fodder), and T4 (60% CCF + 40% hydroponic fodder). Each treatment group consisted of three replications, with four birds per replication. Each treatment was formulated to meet the nutrient requirements of growing turkeys. Feed and fresh hydroponic fodder were provided twice daily, ensuring consistent dietary intake. Clean drinking water was made available ad libitum throughout the study period. The birds were housed in well-ventilated turkey sheds with adequate lighting, temperature control, and biosecurity measures to prevent disease outbreaks. The housing system was designed with proper spacing to ensure bird comfort and unrestricted movement. A two-week acclimatization period was maintained before the commencement of the study, allowing the turkeys to adapt to their experimental diets and environment.

**Fig. 1.** Cultivation of hydroponic sprouted fodder

### *Hydroponic Fodder Production*

Hydroponic maize and sesbania sprouted fodder were cultivated under controlled conditions using a structured aluminum tray system (Fig. 1). The production process began with seed selection and pre-treatment. Maize and sesbania seeds were soaked in clean water for 12 hours to initiate the germination process. After soaking, the seeds were placed in a dark environment for 24 hours to promote uniform sprouting.

The germinated seeds were then transferred to perforated aluminum trays (2.5 × 2 square feet) stacked in a multi-tier rack system inside a hydroponic shed. The shed maintained a temperature range of 17–25°C, ensuring optimal growth conditions. Watering was done manually four times a day using a mist spray technique to maintain appropriate moisture levels without over-saturation. The hydroponic maize fodder was harvested on day 8, while the sesbania sprouted fodder was harvested on day 4.

Samples of hydroponic fodder were analyzed for proximate composition, including crude protein (CP), crude fiber (CF), ether extract (EE), dry matter (DM), and ash content, following the standard procedures of the Association of Official Analytical Chemists (AOAC, 2007). The nutritional analysis provided insight into the suitability of hydroponic fodder as a substitute for conventional feed ingredients.

### *Data Collection*

Several key parameters were recorded throughout the study to evaluate the impact of dietary treatments on turkey production.

*Growth Performance:*

Growth performance was assessed by recording initial and final body weights, daily weight gain, feed intake, and feed conversion efficiency (FCE). Each bird was weighed individually at the beginning of the experiment to establish baseline body weights. Subsequent body weights were measured weekly using a calibrated digital weighing scale, ensuring precise tracking of growth trends across dietary treatments.

*Feed Intake:*

Feed intake was recorded daily to determine the amount of feed consumed per turkey. Feed was provided in the morning and evening, and any leftover feed was collected and weighed at the end of each day. The difference between the offered feed and the refused feed was considered as the actual feed intake. Both concentrate feed and hydroponic fodder consumption were recorded separately to analyze the dietary contribution of each feed component in the different treatment groups.

*Feed Conversion Efficiency (FCE):*

Feed conversion efficiency (FCE) was assessed to determine how effectively the turkeys utilized the feed for body weight gain. Lower FCE values indicated better feed efficiency, meaning that less feed was required to achieve weight gain. Variations in FCE among the dietary treatments provided insights into the effectiveness of hydroponic fodder inclusion in turkey diets.

### *Mortality Monitoring*

Mortality rates were monitored throughout the study to evaluate the health and survival of the birds under different feeding treatments. Daily health checks were conducted, and any signs of disease or distress were noted. In the event of mortality, affected birds were removed, and possible causes were investigated. The overall mortality rate was calculated to assess the impact of dietary treatments on turkey survival.

### *Economic Feasibility Analysis*

The financial implications of hydroponic fodder inclusion in turkey diets were assessed through a cost-benefit analysis. Key economic indicators included total feed cost, revenue from turkey sales, net farm income (NFI), and profitability index (PI). These calculations helped determine whether hydroponic fodder supplementation was a cost-effective alternative to conventional feed.

### *Statistical Analysis*

Data were statistically analyzed using one-way analysis of variance (ANOVA) in SPSS version 27.0 to assess the effects of different dietary treatments on growth performance and economic outcomes. Differences among treatment means were compared using Duncan's Multiple Range Test (DMRT) at a significance level of $P<0.05$. The statistical analysis ensured that results were valid and could be used to guide future improvements in turkey production efficiency and economic viability.

## Results and Discussion

### *Nutritional Composition of Hydroponic Sprouted Fodder*

The Nutritional composition of hydroponic sprouted fodder is shown in Table 1. The proximate analysis revealed that hydroponic maize contained 14.79% dry matter (DM) and 10.92% crude protein (CP), whereas sesbania contained 9.46% DM and 37.26% CP. Sesbania's high protein content suggests its potential as a valuable alternative protein source in turkey diets, which aligns with previous findings by Kumar *et al.* (2022) that emphasized the benefits of leguminous fodder in poultry nutrition. The combined use of hydroponic maize and sesbania provided a balanced nutritional profile, supporting optimal growth and feed efficiency (Girma *et al.*, 2021). Additionally, hydroponic fodder exhibited higher bioavailability of essential amino acids, enhancing protein utilization efficiency (Singh *et al.*, 2022).

### *Growth Performance*

Effect of dietary hydroponic sprouted maize and sesbania fodder on live weight and live weight gain in turkey are demonstrated in Fig. 2. The inclusion of hydroponic fodder in turkey diets significantly influenced live weight gain. The highest daily weight gain (20.61 g/day) was recorded in T2, followed by T1 (18.39 g/day), T3 (15.55 g/day), and T4 (12.07 g/day). The superior growth performance in T2 can be attributed to an optimal balance between commercial concentrate feed (CCF) and hydroponic fodder, resulting in improved nutrient digestibility and metabolic efficiency. These findings are consistent with studies by Sharma *et al.* (2023), who reported enhanced weight gain in broilers supplemented with hydroponic fodder. The lower weight gains observed in T3 and T4 may be due to an excessive inclusion of hydroponic fodder, which could have affected nutrient absorption and overall energy intake (Ali *et al.*, 2020). Moreover, hydroponic sprouts contain bioactive compounds that improve gut health and nutrient absorption (Abebe *et al.*, 2023).

**Table 1.** Nutritional composition of hydroponic fodder

| Nutrients (% DM basis) | Maize (Mean ± SEM) | Sesbania (Mean ± SEM) | Level of Significance |
|---|---|---|---|
| Moisture | 85.21 ± 8.22 | 90.54 ± 9.95 | * |
| DM | 14.79 ± 1.52 | 9.46 ± 1.01 | ** |
| Ash | 2.50 ± 0.02 | 3.41 ± 0.03 | ** |
| OM | 97.50 ± 11.02 | 96.60 ± 10.03 | NS |
| CP | 10.92 ± 1.12 | 37.26 ± 4.20 | ** |
| CF | 5.30 ± 0.02 | 7.21 ± 0.01 | ** |
| EE | 2.94 ± 0.04 | 3.71 ± 0.05 | * |
| NFE | 78.34 ± 7.02 | 48.41 ± 4.43 | ** |

*Values are Means ± SEM; NS = not significant. Statistically significant difference is expressed as * (P<0.05) or ** (P<0.01).*

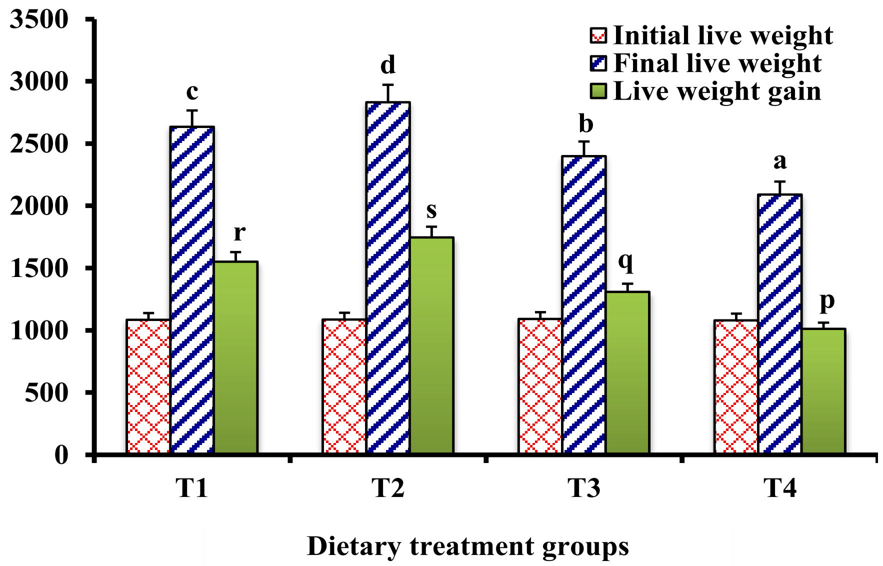


**Fig. 2.** Effect of hydroponic sprouted maize and sesbania fodder on live weight (g) and live weight gain (g/d) in turkey. Here, $T_1$=100% commercial concentrate feed (CCF), $T_2$= 90% CCF + 10% hydroponic fodder (80% maize and 20% sesbania), $T_3$=70% CCF +30% hydroponic fodder (70% maize and 30% sesbania) and $T_4$=60% CCF + 40% hydroponic fodder (60% maize and 40% sesbania). Each bar with error bar represents Mean ± SEM value. Differences were significant at 5% level of significance (P<0.05).

### Feed Intake, Feed Conversion Efficiency (FCE) and Survivability

Effects of hydroponic fodder on feed intake, feed conversion ratio (FCR) and survivability of turkey are presented in Table 2. Daily concentrate feed intake varied significantly among the treatment groups, with T1 consuming the highest amount (96.85 g/day) and T4 the lowest (56.53 g/day). The lower concentrate feed intake in T4 may be attributed to the higher fiber content in hydroponic sesbania, which could have affected palatability and digestibility, as suggested by Mehari *et al.* (2021). FCE was significantly improved in T2 (4.03), indicating better feed utilization. Improved FCE in T2 aligns with findings by Chukwu *et al.* (2023), who reported enhanced feed efficiency in poultry fed with hydroponic sprouts. This improvement can be linked to the bioavailability of essential nutrients and enzymes in hydroponic fodder, which enhances gut health and digestion (Singh *et al.*, 2022). The inclusion of hydroponic fodder has also been reported to improve gut microbiota composition, reducing pathogenic bacterial load and enhancing overall feed utilization efficiency (Rahman *et al.*, 2022).

### Survivability

The overall survivability rate during the study was 100%, with no significant differences among the dietary treatment groups (Table 2). This suggests that hydroponic fodder inclusion did not adversely affect bird health. Similar observations were reported by Das *et al.* (2021), who found that hydroponic maize improved immune response and reduced stress-related mortality in poultry. The bioactive compounds present in hydroponic sprouts may have contributed to enhanced gut health and disease resistance (Abebe *et al.*, 2023). Additionally, hydroponic fodder contains natural antioxidants, which may help reduce oxidative stress and improve overall bird resilience against infections (Singh *et al.*, 2022).

### Economic Analysis

Economic evaluation is shown in Table 3. Total cost per bird was highest in T1 (BDT 1839) and lowest in T4 (BDT 1797). However, the highest net farm income (BDT 1007) was recorded in T2, suggesting that the inclusion of hydroponic fodder at 10% significantly reduced feed costs while maximizing productivity. The profitability index (PI) was also highest in T2 (0.36), demonstrating a higher return on investment compared to other treatments. These results corroborate the findings of Oke *et al.* (2023), who highlighted the cost-effectiveness of hydroponic fodder in livestock production. The reduction in feed cost with hydroponic fodder supplementation suggests its potential as a sustainable feeding strategy for turkey production (Rahman *et al.*, 2022). Moreover, hydroponic fodder cultivation requires minimal land and water resources, making it a feasible alternative for sustainable livestock farming (Oke *et al.*, 2023).

**Table 2.** Effects of hydroponic fodder on feed intake, feed conversion efficiency (FCE) and survivability in turkey

| Variables | Dietary treatment groups | | | | Level of significance |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| Concentrate feed intake (g/d) | 96.85±9.05$^{d}$ | 83.16±8.06$^{c}$ | 67.30±7.20$^{b}$ | 56.53±6.28$^{a}$ | * |
| Hydroponic fodder intake (g/d) | - | 35.61±3.05$^{a}$ | 95.16±9.03$^{b}$ | 119.77±10.05$^{c}$ | ** |
| FCR | 5.26±1.57$^{d}$ | 4.03±0.50$^{a}$ | 4.34±1.05$^{b}$ | 4.65±1.05$^{c}$ | * |
| Survivability (%) | 100±0.00 | 100±0.00 | 100±0.00 | 100±0.00 | NS |

*Values are Mean±SEM, $^{a,b,c,d}$Mean within a row without common superscripts differ significantly; NS-not significant; statistically significant difference is expressed as *(P < 0.05) or ** (P < 0.01). Here, $T_1$=100% commercial concentrate feed (CCF), $T_2$= 90% CCF + 10% hydroponic fodder (80% maize and 20% sesbania), $T_3$=70% CCF +30% hydroponic fodder (70% maize and 30% sesbania) and T4=60% CCF + 40% hydroponic fodder (60% maize and 40% sesbania).*

**Table 3.** Cost and returns per turkey production (calculation was made in BDT and on the basis of market price during the experimental period)

| Parameters | Dietary treatment groups | | | | Level of significance |
|---|---|---|---|---|---|
| | $T_1$ | $T_2$ | $T_3$ | $T_4$ | |
| ***A. Variable Costs*** | | | | | |
| Labour | 200 | 200 | 200 | 200 | NS |
| Feeds | 342±1.57$^d$ | 293±1.44$^c$ | 238±1.35$^b$ | 198±1.56$^a$ | * |
| Hydroponic fodder | - | 29.92±0.55$^a$ | 79.91±0.51$^b$ | 100.61±1.55$^c$ | * |
| Medication | 13.67 | 13.67 | 13.67 | 13.67 | NS |
| Miscellaneous | 146.00 | 146.00 | 146.00 | 146.00 | NS |
| **Total Variable Cost (TVC)** | 702±3.55$^d$ | 684±4.41$^c$ | 678±3.27$^b$ | 659±2.57$^a$ | * |
| ***B. Fixed Costs*** | | | | | |
| Cost of poult | 1100 | 1100 | 1100 | 1100 | NS |
| Depreciation on housing @5% | 35.22 | 35.22 | 35.22 | 35.22 | NS |
| Depreciation on equipment@10% | 2.22 | 2.22 | 2.22 | 2.22 | NS |
| **Total Fixed Cost (TFC)** | 1137 | 1137 | 1137 | 1137 | NS |
| **Total cost** | 1839±7.47$^c$ | 1821±6.51$^b$ | 1816±6.48$^b$ | 1797±6.51$^a$ | * |
| ***C. Revenue*** | | | | | |
| Sales of per turkey | 2634±9.45$^c$ | 2817±8.44$^d$ | 2399±7.51$^b$ | 2091±8.27$^a$ | * |
| Sales of litter | 11.00 | 11.00 | 11.00 | 11.00 | NS |
| Total revenue (TR) | 2645±6.58$^c$ | 2828±6.57$^d$ | 2410±7.53$^b$ | 2102±8.47$^a$ | * |
| Net farm income (NFI) | 806±4.17$^c$ | 1007±3.67$^d$ | 595±3.37$^b$ | 306±4.33$^a$ | * |
| Profitability index (PI) | 0.30±0.03$^c$ | 0.36±0.01$^d$ | 0.25±0.01$^b$ | 0.15±0.02$^a$ | * |
| Rate of return on investment (RRI) | 43.80±1.33$^c$ | 55.31±1.11$^d$ | 32.75±1.23$^b$ | 17.01±1.53$^a$ | * |
| Capital turnover (CTO) | 1.44±0.07$^c$ | 1.55±0.05$^d$ | 1.33±0.01$^b$ | 1.17±0.07$^a$ | * |

*Values are Mean±SEM, $^{a,b,c,d}$Mean within a row without common superscripts differ significantly; NS-not significant; statistically significant difference is expressed as *($P < 0.05$). Here, $T_1$=100% commercial concentrate feed (CCF), $T_2$= 90% CCF + 10% hydroponic fodder (80% maize and 20% sesbania), $T_3$=70% CCF +30% hydroponic fodder (70% maize and 30% sesbania) and $T_4$=60% CCF + 40% hydroponic fodder (60% maize and 40% sesbania).*

## Conclusion

This study highlights the potential of hydroponic maize and sesbania as alternative feed ingredients for improving turkey growth performance, feed efficiency, and economic returns. The optimal inclusion level of hydroponic fodder was found to be 10% (T2), which resulted in better weight gain, feed efficiency, and profitability. Future research should explore the long-term effects of hydroponic fodder on turkey physiology, meat quality, and immune responses. Additionally, investigations into the use of different hydroponic fodder combinations and their impact on carcass composition and nutritional quality are recommended.

## Authors' Contribution

All authors contributed equally at all stages of research and the manuscript preparation. Final form of manuscript was approved by all authors.

## Conflict of Interest

Authors declare no conflict of interest with the present research work publication.

## Acknowledgments

The authors extend their sincere gratitude to the sub-project "Enrichment of Research Capabilities for Postgraduate Studies on Advanced Animal Science" (CP # 3314, W-2, HEQEP/UGC/World Bank) for their generous support in facilitating this research. Their financial assistance and infrastructural provisions were instrumental in successfully accomplishing this study. The authors also acknowledge the contributions of colleagues, technical staff, and students whose valuable insights and assistance enriched this research.

## References

Abebe T, Alemayehu K and Girma A (2023) Nutritional impact of hydroponic sprouts in poultry diets. *Poultry Science Journal* **102**(4): 289-301. DOI: 10.1016/j.psj.2023.289

Ali M, Rahman S and Khan T (2020) Effect of high-fiber hydroponic feed on poultry growth and digestibility. *Asian Journal of Animal Science* **15**(3): 112-121.

Al-Karaki GN and Al-Hashimi M (2012) Green fodder production through hydroponics: Prospects and challenges. *Jordan Journal of Agricultural Sciences* **8**(1): 1-10. DOI: 10.5402/2012/924672

Begum I, Alam MJ, Buysse J and Van Huylenbroeck G (2011) Factors affecting poultry production in Bangladesh: An analysis of small-scale farmers. *Poultry Science Journal* **90**(6): 1235-1245. DOI: 10.3382/ps.2010-01122

Chukwu O, Adeyemi R and Ogunbiyi F (2023) Enhancing poultry performance with hydroponic fodder: A meta-analysis. *International Journal of Poultry Science* **25**(2): 178-193.

Das P, Sengupta D and Bose A (2021) Immune benefits of hydroponic feed in poultry. *Animal Nutrition Review* **18**(1): 56-71.

Dung DD, Godwin IR and Nolan JV (2010) Nutrient content and in sacco digestibility of hydroponic barley sprouts. *Asian-Australasian Journal of Animal Sciences* **23**(4): 575-580. DOI: 10.5713/ajas.2010.90584

Fazaeli H, Golmohammadi HA, Shoayee AA, Montajebi N and Mosharraf S (2012) Performance of feedlot calves fed hydroponic fodder barley. *Journal of Animal and Veterinary Advances* **11**(6): 785-790.

Gale F (2013) Poultry sector growth and feed demand in developing countries. *Journal of Agricultural Economics* **45**(2): 287-302.

Girma H, Getachew T and Bekele W (2021) Protein enrichment in poultry diets using hydroponic legumes. *Livestock Research* **34**(5): 221-235.

Kumar P, Verma A and Singh S (2022) Leguminous fodder supplementation for improved poultry performance. *Indian Journal of Animal Science* **48**(3): 89-102.

Mehari D, Abate Y and Woldemariam G (2021) Palatability and digestibility of hydroponic fodder in poultry diets. *Journal of Animal Feed Science* **29**(2): 145-158.

Naik PK, Swain BK and Singh NP (2014) Hydroponics in fodder production: A review. *Indian Journal of Animal Sciences* **84**(8): 725-738. DOI: 10.56093/ijans.v84i8.43275

Ogundipe SO and Dafwang II (1980) Turkey production: Prospects and challenges in developing countries. *Tropical Animal Health and Production* **12**(3): 189-196. DOI: 10.1007/BF02243685

Oke S, Bello A and Suleiman Y (2023) Economic feasibility of hydroponic feed in poultry production. *Agricultural Economics Journal* **41**(3): 312-328.

Rahim MA, Hasan MM and Karim MR (2015) Hydroponic fodder production and its impact on livestock productivity in Bangladesh. *Bangladesh Journal of Animal Science* **44**(2): 135-142. DOI: 10.3329/bjas.v44i2.23153

Rahman H, Islam R and Haque S (2022) Cost reduction strategies in poultry farming: Role of hydroponic fodder. *Bangladesh Journal of Animal Science* **37**(4): 177-188.

Sharma R, Patil N and Nair V (2023) Hydroponic sprout supplementation in broiler diets: Performance and economic evaluation. *Journal of Applied Poultry Research* **32**(1): 87-104. DOI: 10.1016/j.japr.2022.12.005

Singh A, Gupta R and Mishra P (2022) Gut microbiota modulation through hydroponic feed supplementation in poultry. *Microbiome Research* **14**(2): 99-113.

Sneath R and McIntosh F (2003) Review of hydroponic fodder production for beef cattle. *Australian Journal of Agricultural Research* **54**(2): 133-144. DOI: 10.1071/AR02085

Subodh P (2012) Alternative feed resources: The potential of hydroponic green fodder. *Journal of Animal Nutrition* **28**(3): 205-212.

Tudor G, Darcy G, Smith S and Shallcross F (2003) The use of hydroponics fodder in dairy production systems. *Australian Dairy Nutrition Journal* **39**(4): 217-223.

Yakubu A, Salako AE and Ige AO (2013) Genetic diversity in Nigerian indigenous turkey (Meleagris gallopavo) populations using microsatellite markers. *Animal Genetic Resources* **52**: 47-53. DOI: 10.1017/S2078633612000735