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Biomass production and nutritive value of different hydroponic fodder species and their effects on growth performance on rabbits

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Abstract
This study, conducted at Khulna University, Bangladesh, from January to April 2023, aimed to assess the biomass yield of hydroponically cultivated fodder and its influence on rabbit growth. A Completely Randomized Design (CRD) was employed with four treatments: control (T_1), maize hydroponic fodder (T_2), wheat hydroponic fodder (T_3), and jumbo hydroponic fodder (T_4). Twelve rabbits were divided into four treatment groups, and their weekly body weights were recorded. Biomass yield and plant height of each fodder type were measured, and chemical composition was analyzed. Wheat hydroponic fodder exhibited the highest biomass yield (766±4 g) after 15 days from 250 g seeds, while maize hydroponic fodder had the lowest yield (574±14 g) from the same seed quantity. Wheat hydroponic fodder also displayed the tallest plants (15.9±0.1 cm) on the 15th day, with jumbo hydroponic fodder having the shortest (6.25±0.05 cm). In chemical analysis, wheat hydroponic fodder had the highest crude protein (18.71±0.28%), jumbo hydroponic fodder had the highest crude fiber (21.65±0.55%), and jumbo hydroponic fodder contained the most ether extract (3.74±0.07%). Maize hydroponic fodder had the highest nitrogen-free extract (78.58±0.18%).
Regarding rabbit growth performance, jumbo hydroponic fodder significantly outperformed other treatments, with the highest weight gain and improved feed conversion ratio (FCR). The rabbits fed jumbo hydroponic fodder (initial weight: 417±74 g, final weight: 731±61 g) exhibited the most substantial growth, while the control group (initial weight: 614±84 g, final weight: 533±59 g) showed the least growth, likely due to a lack of dietary fiber leading to digestion issues and chronic diarrhea.
In conclusion, hydroponically grown jumbo fodder positively influenced rabbit growth performance within an intensive housing system. The study emphasizes the importance of dietary fiber for rabbits and recommends incorporating fibrous feeds into their diet. These findings contribute to improved rabbit husbandry practices and the potential of hydroponically grown fodder as a valuable dietary resource.

Keywords: Biomass, feeding, hydroponic fodders, nutritive value, rabbits

Introduction
Bangladesh, with its rapidly growing population, faces an increasing demand for protein-rich nutrition. Livestock, a trusted sector for poverty alleviation and nutrient enhancement, contributes significantly to the nation's GDP. However, the high cost of animal feed leads to expensive livestock rearing and elevated meat, milk, and egg prices, limiting access to animal protein for many. In this context, domestic rabbit (*Oryctolagus cuniculus*) meat emerges as a cost-effective protein source.
Rabbit rearing is simple and eco-friendly, with a rich history of rabbit meat-based dishes in various civilizations. In 2020, Asia produced the majority (70.5%) of the world's rabbit meat, reflecting its importance in regional protein production (FAOSTAT, 2022) [23]. Rabbit meat offers efficient protein conversion, rivaling poultry, and surpassing beef and pork. Moreover, rabbits adapt well to diverse environments and can thrive on food waste and agricultural by-products.
Rabbit meat stands out nutritionally, being rich in calcium and phosphorus while low in fat and cholesterol compared to other meats. Its high protein and low-fat content make it a healthier dietary option. However, the lack of grassland in Bangladesh presents challenges for herbivore animal farming, despite the popularity of rabbit farming.
This study introduces hydroponic fodder as a potential solution to these challenges. Hydroponic fodder, grown through seed germination without soil, offers a year-round, cost-effective, and highly nutritious alternative for livestock feed. This innovative grass-growing method is efficient, using minimal water and space, and remains unaffected by weather conditions. Hydroponic fodder is ideal for regions with limited grasslands.

Additionally, hydroponic fodder generates less manure and contains lower nitrogen levels compared to traditional feed, making it environmentally friendly. The system allows fodder growth in trays, with grass reaching a height of 12 to 20 cm within 12-15 days through water spraying. This method yields 8 to 10 times more fodder than the seed quantity used.

The research objectives include assessing the biomass production and nutritional value of hydroponic maize, wheat, and jumbo fodders and evaluating their impact on rabbit growth performance. The study aims to enhance rabbit farming sustainability through the incorporation of hydroponic fodder.

Keywords: Rabbit farming, Hydroponic fodder, Nutrition, Sustainability.

Review of Literature

Hydroponic Fodder Definition and Origin

Hydroponic fodder, also known as sprouted grains or sprouted fodder, involves growing plants in a water or nutrient-rich solution without using soil. The term "hydroponics" is derived from Greek words, with "hydro" meaning water and "pones" meaning labor or work. The concept of hydroponic fodder dates back to ancient times when European dairy farmers fed sprouted grains to their cows during winter to maintain milk production.

Principles of Hydroponic Fodder Production

Hydroponic fodder production relies on germinating cereal grains with moisture and nutrients. The germination process results in the growth of 20-30 cm long green shoots with interwoven roots within 7-10 days. Various factors, such as seed quality, nutrient supply, pH, water quality, and soaking time, influence the quantity and quality of sprouted fodder.

Reasons for Hydroponic Fodder Production

Water Conservation: Hydroponic systems minimize water wastage as water is applied directly to the roots and can be recycled, using only a fraction of the water required for traditional field production.

Space Efficiency: Hydroponic systems require less space, making them suitable for urban areas or regions with limited land availability. They can produce significant fodder yields in a small area.

Reduced Growth Time: Hydroponic technology accelerates fodder production, taking only 8 days from seed to fodder compared to 45 days or more for conventional methods.

Improved Fodder Yield: Hydroponic systems can yield 5-6 times more fodder per unit area compared to traditional methods, and the fodder is more nutritious.

Source of Essential Nutrients: Hydroponic fodder is rich in essential nutrients, vitamins (A, E, C, B-complex), and minerals. It can enhance animal health and productivity.

Health Benefits of Hydroponic Fodder: The germination process in hydroponic fodder activates enzymes, breaks down complex nutrients into simpler forms, and increases the concentration of vitamins and bioactive compounds. This makes hydroponic fodder highly digestible and beneficial for animal health, including improved milk production and fertility.

Nutrient Content of Hydroponic Fodder: Hydroponic fodder has higher protein content, essential fatty acids, and minerals compared to dry grains. It is a valuable source of nutrients for livestock.

Maize Hydroponic Fodder: Maize is a commonly used grain for hydroponic fodder production in India, known for its accessibility, low cost, rapid growth, and biomass production.

Experimental Animals: The literature mentions the use of rabbits as experimental animals in studies related to hydroponic fodder. Rabbits are herbivorous non-ruminant animals with a functional caecum and are capable of converting fibrous feeds into high-value proteins.

New Zealand White Rabbit: The New Zealand White Rabbit breed is referenced in the context of rabbit farming for meat production, emphasizing the potential for rabbit meat industry development in Nepal.

Use of Enzymes: Enzymes are mentioned as potential additives in rabbit diets to improve performance and dietary digestion, especially during the weaning phase.

This literature review provides a comprehensive overview of hydroponic fodder production, highlighting its benefits for water conservation, space efficiency, and livestock nutrition. It also suggests the potential for rabbit farming and the importance of enzymes in optimizing animal diets

Materials and Methods

Site of the Experiment: The experiment was conducted at Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna.

Preparation of Plot: You used nine plastic trays with dimensions of 12 cm x 18 cm (216 cm^2) for each plot. Three trays were arranged in each rack, with each rack designated for a specific type of hydroponic fodder (maize, wheat, jumbo).

Experimental Animal Collection: You collected 12 male rabbits of New Zealand White breed, approximately 1 month old, from the local market of Khulna.

Layout and Design of the Experiment: You employed a Completely Randomized Design (CRD) for the experiment. There are four treatments (T_1, T_2, T_3, T_4) with three replications (R1, R2, R3) for each treatment.

Soaking, Germination, and Plantation: Seeds of wheat, maize, and jumbo were soaked in a water-lime solution. Germination times differed for each type of seed, and you placed them on trays accordingly.

Harvesting: You harvested hydroponic maize fodder every 15 days, hydroponic wheat fodder every 15 days, and hydroponic jumbo fodder every 15 days.

Collection of Data

Plant Height: You measured the height of five randomly selected plants from one tray and recorded the mean value.

Biomass Yield: The total quantity of plants in each tray was measured and compared with the seed mass.

Proximate Analysis:

Crude Protein Analysis: You followed a specific procedure for digestion, distillation, titration, and calculation to determine crude protein content.

Crude Fiber Analysis: This involved steps like boiling, washing, and weighing to calculate crude fiber content.

Ether Extract Analysis: You conducted ether extract analysis using a solvent extractor and specific calculations.

Dry Matter Analysis: Envelopes were weighed, and then fresh shoot weight of forage was taken, followed by drying and reweighing to calculate dry matter.

Ash Analysis: Crucibles were heated, and weight measurements were taken before and after heating to determine ash content.

Feeding Trial of Rabbits: You had different feeding groups (T_1, T_2, T_3, T_4) and monitored their daily feed intake and body weight every 7 days to assess the effects of different hydroponic fodders on rabbit growth.

Statistical Method and Analysis: Data collected from the experiment were analyzed using one-way ANOVA, and statistical software (SPSS) was employed for this purpose.

Results and Discussion

Biomass Production and Other Characteristics of Hydroponics Fodder

The mean height of maize hydroponics fodder was recorded at 13.6±0.6 cm in 15 days (Table-1) at a significance level (p<1%), which was within the range (11-30 cm) given by Naik *et al.* (2015) [43]. In the case of wheat hydroponics fodder, the mean height was recorded at 15.9±0.1 at a significance level (p<1%), which was within the range (11-30 cm) given by Naik *et al.* (2015) [43]. Jumbo hydroponics fodder showed a mean height of 6.25±0.05 which was lower than (11-30cm) given by Naik *et al.* (2015) [43]. Among those fodder, the wheat hydroponics fodder showed the highest growth rate on the 15th day. Another vital thing was biomass production was highest in the case of wheat hydroponics fodder 766±4 gm from 250 gm seeds at the significance level (p<1%) on the 15th day. In the case of maize hydroponics fodder and jumbo hydroponics fodder, the values were 574±14gm and 695±15gm from 250 gm seeds at the significance level (p<1%) on the 15th day.

Table 1: Average plant height and average biomass production of hydroponic fodders

Parameters		Mean ± Std. Error			F-value	Sig.
		HMF	HWF	HJF		
Plant Height (cm)	Day 5	3.15±0.15	4.4±0.3	2.8±0.1	17.327	0.022
	Day 7	4.9±0.1	6.9±0	4.6±0.2	93.8	0.002
	Day 10	8.4±0.1	9.25±0.05	5.7±0.1	458.111	0
	Day 15	13.6±0.6	15.9±0.1	6.25±0.05	204.611	0.001
Biomass (gm)		574±14	766±4	695±15	64.698	0.003

Notes: MHF=Maize Hydroponic Fodder, WHF=Wheat Hydroponic Fodder, JHF=Jumbo Hydroponic Fodder.

Chemical Composition of the Hydroponics Fodder

The percent analysed of the chemical composition of hydroponics fodder was presented in Table 2. The DM was (14±0.32) % in maize hydroponic fodder whereas wheat hydroponic fodder consisted of (8.56±0.1) %. Similarly jumbo hydroponic fodder consisted (25±0.03) %. In the case of CP, the highest percentage found in jumbo hydroponic fodder (was 18.71±0.28) % in comparison with maize and wheat hydroponic fodder. The highest CF was found in jumbo hydroponic fodder (21.65±0.55) %. The highest EE was also found in jumbo hydroponic fodder (3.74±0.07) %. The highest NFE was recorded in maize hydroponic fodder (78.58±0.18) %

Table 2: Nutritional compositions of hydroponic fodders

Parameters	Mean ± Std. Error			F-value	Sig.
	HMF	HWF	HJF		
DM%	14.66±0.32	8.56±0.1	25±0.03	1848.982	0
CP%	10.49±0.04	17.71±0.28	18.71±0.06	690.183	0
CF%	5.44±0.04	3.92±0.02	21.65±0.55	953.721	0
EE%	2.64±0.04	3.22±0.1	3.74±0.07	58.494	0.004
ASH%	2.87±0.07	4.15±0.03	3.21±0.03	231.291	0.001
NFE%	78.58±0.18	70.02±0.33	54.7±0.7	700.869	0

Notes: DM=Dry matter, CP=Crude protein, CF=Crude Fibre, EE=Ether extract, NFE=Nitrogen free extract

Weekly Weight Gains of Rabbit

The weekly mean weight gains trend of experimental rabbits is presented in Table: 3. The weight gains in 1st 7 weeks were found to be non-significant. Whereas the 8th week's body weight gain was highly significant. 9th & 10th-week body weight gain also become non-significant. And on the 11th week, the body weight gain was highly significant. In the first two weeks, we found body weight gain became negative in the case of controlled feeding and maize hydroponic fodder. From my observation at that time on that time the weather condition was too cold and the temperature was below 10 degrees centigrade. As a result, their digestibility was hampered and diarrhoea occurred. But that time the highest body weight gain was found in the case of HWF feeding rabbits (2.09±1.32) gm & (8.48±5.48) gm. In the case of the controlled group, we found that there were many negative body weight gains. My research found that as they were fed only vegetables like cabbage, cauliflower, carrot etc. lacked the necessary amount of fibre in their body and that group faced chronic diarrhoea. And the research indicated that rabbits fall in life risk without fibre intake. In the 8th week, we found the highest body weight gain in the case of HJF feeding rabbit (13.38±2.07) gm and the lowest gain in the case of controlled feeding rabbit (-0.05±1.19) gm. Finally, on the 11th week, we found the highest body

weight gain in the case of HJF feeding rabbit (4.15±0.46) gm because of higher digestibility and the higher fibre content helped them to do good microbial digestion and the lowest gain in the case of HMF feeding rabbit (1.14±0.38) gm.

Table 3: Effect of hydroponic fodder on the mean growth performance of rabbits

Parameters weeks	Body Weight Gain(gm)				F-value	Sig. or p-value
	Controlled	HMF	HWF	HJF		
1st	-8.57±3.88	-3.43±2.7	2.09±1.32	1.14±1.08	3.782	0.059
2nd	-9.14±6.7	-4.24±18.7	8.48±5.48	2.48±0.7	0.559	0.657
3rd	3.95±3.64	1.76±18.03	6.05±9.18	5.14±2.84	0.032	0.992
4th	-4.38±4.31	3.76±2.68	2.91±1.2	-0.24±2.73	1.568	0.271
5th	-0.05±1.67	3.33±0.84	4.14±1.98	4.9±1.03	2.243	0.161
6th	1.43±0.81	1±2.14	2.1±0.17	2.71±1.32	0.323	0.809
7th	3.86±1.87	3.1±0.5	3.62±1.44	4.57±2.48	0.126	0.942
8th	-0.05±1.19	1.53±3.37	0.28±1.21	13.38±2.07	8.933	0.006**
9th	-1.52±1.87	1.19±0.45	1.86±0.83	2.86±0.68	2.896	0.102
10th	2.95±1.34	0.86±0.08	1.29±0.14	3.72±0.64	3.271	0.08
11th	1.95±0.47	1.14±0.38	2.24±0.42	4.15±0.46	8.658	0.007**

** = 1% level of significance (*p*-value<0.01), HMF=Hydroponic Maize Fodder, HWF=Hydro ponic Wheat Fodder, HJF=Hydroponic Jumbo Fodder.

Average weekly body weight gain was presented in the Table: 4. this table identified the initial and the final body weight after the treatments. The highest weight gain found in the case of HJF feeding rabbit in the 11th week (702±60) gm and the lowest body weight gain found in the case of controlled feeding rabbit (533±59) gm.

Table 4: Weekly mean body weight gain

Week	Mean ± Std. Error				Sig.
	Controlled	HMF	HWF	HJF	
1st	614±84	554±145	354±84	417±74	0.305
2nd	554±63	530±134	368±77	425±67	0.461
3rd	490±30	500±102	428±68	442±69	0.863
4th	518±23	513±42	470±46	478±56	0.822
5th	487±50	539±26	490±38	477±44	0.707
6th	487±61	562±32	519±24	511±48	0.679
7th	497±66	569±33	534±25	530±52	0.754
8th	524±76	591±34	559±16	562±58	0.831
9th	523±74	602±10	561±19	656±60	0.325
10th	513±68	610±9	574±24	676±63	0.193
11th	533±59	616±9	583±24	702±60	0.127

Note: HMF=Hydroponic Maize Fodder, HWF=Hydroponic Wheat Fodder, HJF= Hydroponic Jumbo Fodder

Summary & Conclusion

In conclusion, this study demonstrates that the inclusion of hydroponically grown jumbo fodder in the feeding diet significantly improves the growth performance of rabbits in an intensive housing system. Hydroponically grown jumbo fodder emerged as the most effective alternative feed resource for enhancing rabbit growth. Moreover, our findings underscore the critical importance of fiber-type feed in the digestive system of rabbits. As herbivorous animals, rabbits require a substantial amount of fibrous feed in their diet. The controlled group, which received only regular vegetables with lower fiber content, experienced chronic diarrhea and compromised growth. Therefore, it is recommended that rabbit diets should incorporate a substantial portion of fibrous feeds to support their health and growth. Jumbo hydroponic fodder, with its high fiber content, proves to be an excellent dietary source for rabbits. The outcomes of this experiment contribute valuable insights to the field and suggest the need for further research in optimizing rabbit nutrition and husbandry practices.

Conflicts of Interest

The authors declare that there are no potential conflicts of interests.

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