**Evaluating the effect of Heteronitrogenous and Heterolipidic diets (Commercial Feeds) on Growth Parameters of Rainbow trout (Oncorhynchus mykiss) fingerlings in Meghalaya**

**ABSTRACT**

Rainbow trout is a popular candidate species in aquaculture due to its rapid growth rate, excellent feed conversion capacity and high market value. The success of Rainbow trout farming relies heavily on maintaining optimal water quality parameters, which include water flow, temperature, dissolved oxygen, pH, ammonia and nitrate levels. This study investigated the growth performance of Rainbow trout (*Oncorhynchus mykiss*) fingerlings in the hilly region of Meghalaya, focusing on the impact of heteronitrogenous and heterolipidic formulated diets. The experiment was conducted between September 2024 and January 2025, under specific water conditions, including temperature, pH, dissolved oxygen, total alkalinity, hardness, ammonia, carbon dioxide and water flow. In this study, there was one control and three treatments with 3 replications. The growth parameters, such as growth rate, specific growth rate, weight gain, percentage weight gain and survival rate were monitored during the studies. One-way ANOVA was followed by Tukey HSD’s multiple range test to determine differences between treatment means. All the statistical analysis was performed using SPSS (Version 25.0). The weight gain, percent weight gain and SGR value were found significantly highest in control (1.71 ± 0.03 % day-1) with the lowest FCR of 0.96 ± 0.04. High FER was recorded in control (1.042 ± 0.05) and PER (2.315 ± 0.09) fed with 45% CP. The outcomes of this study offer critical insights into the effectiveness of commercial feed types for aquaculture in Meghalaya, emphasizing the need for customized feeding strategies to enhance Rainbow trout growth in cold-water ecosystems. The work emphasizes the relevance of species-specific diet formulation that considers nutritional requirements and points out that commercially obtainable feeds may prove effective as long as their protein and lipid contents were attuned to physiological and metabolic demand. Future studies must investigate the long-term effects of the diets on body constitution, digestive enzyme profiles, economic acceptability, and compatibility for incorporation of local feed components to make the operation less dependent on external commercial feeds and more sustainable at the local level.

**Keywords:** Heteronitrogenous, Heterolipidic feed, Digestibility, Growth performance, Rainbow trout

**1.0 Introduction**

Fish often suffered starvation in the natural process of overwintering. After a long period of overwintering starvation, the actual demand of nutrients in refeeding diets for fish may be different from the appropriate demand level in normal culture environment. Animal growth is directly related to food intake. Different species and different growth stages of the same species have different tolerance to starvation (Wu et al., 2020; D’Agaro et al., 2022). Trout was first introduced in India during the late 19th century, and which is generally believed that the initial introductions occurred around the late 1800s primarily by British colonial administrators **(Devaa *et al*.2021)**. In India, Himachal Pradesh is the leading state in the production of Rainbow trout farming **(Singh *et al*.2017)**. They contributed approximately 50 percent of the total production of the country. When compared to present production (842.23 MT in 2015-16) with from 2004-05, with only 147 MT was a significant leap and for achieving this level of success, the credit goes primarily to the farmers, then to the State fisheries department / Directorate, ICAR-DCFR Frontier KVKs, *etc*. Trout farming supports economic growth in rural areas and offers a sustainable food option, given its lower ecological impact than livestock like lamb and beef. To obtain a greater yield of fish such as rainbow trout, strategies have been designed to take advantage of the by products. This is the case of the skin, which contains nutrients of interest for human health and industry, such as lipids (essential fatty acids) and, to a greater extent, proteins (collagen and essential amino acids) (Escamilla-Rosales et al., 2024;). Rainbow trout farming in India was growing rapidly and progressively. It was cultured mainly in Himachal Pradesh, Sikkim, Jammu and Kashmir and Uttarakhand. The trout production in Jammu and Kashmir, Himachal Pradesh and Sikkim were 265, 417, 120 MT respectively, while in other states such as Arunachal Pradesh and Uttarakhand was 40 mt during the year 2015-16. Rainbow trout is a popular candidate species in aquaculture due to its rapid growth rate, excellent feed conversion capacity and high market value. The success of Rainbow trout farming relies heavily on maintaining optimal water quality parameters, which include water flow, temperature, dissolved oxygen, pH, ammonia and nitrate levels. In freshwater systems, Rainbow trout thrive in cool, well-oxygenated waters. Studies have shown that ideal temperatures range between 12°C and 18°C for optimal growth. Dissolved oxygen was critical, as levels below 5 mg/L can lead to stress and decreased growth rates. Furthermore, the pH level, typically maintained between 6.5 and 8.5, affects the fish's physiological processes and overall well-being. In hilly regions, where aquaculture operations may face challenges such as fluctuating water quality and limited natural food sources, the use of nutritionally balanced formulated feeds becomes essential. Formulated feeds were designed to provide optimal nutrition, promoting efficient growth and health in fish. This research will assess key growth parameters such as weight gain, length increase, feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER), specific growth rate (SGR) and survival rates of Rainbow trout fed with varying formulated diets. Accordingly, feed is the most important cost item in Rainbow trout culture and the cost of feeding generally ranges between 40-70% of the total production cost **(Lasner *et al*.2017)**. Early feeds for farming Rainbow trout were moist feeds based on animal protein sources **(Rumsey, 1994).** Feeds for Rainbow trout must supply all the essential amino acids, fatty acids, vitamins, minerals and energy-yielding macronutrients (protein, lipid and carbohydrate) at required levels, to meet the physiological needs for maintenance and growth.

Digestive enzyme activities, intestinal nutrient absorption and the apparent digestibility of nutrients and energy in Rainbow trout feeds are influenced by several factors including the ingredient source, physical form and level of inclusion; diet composition; interaction between nutrients; feeding rate and frequency; rearing temperature and salinity and diet manufacturing process **(NRC, 2011; Bakke *et al*.,2011).** For instance, water temperature and feeding frequency are known to considerably affect the starch digestibility in Rainbow trout **(Yamamoto *et al*.,2007).** Besides, the time taken for gastric emptying and complete evacuation of food from the intestine is closely related to the digestive and nutrient absorption processes, as well as the return of appetite. However, the gut transit time is influenced by various factors such as the size of fish, rearing temperature, autonomic nerves, endocrine factors (*e.g.* cholecystokinin) and diet composition **(Grove, 1986; Olsson and Holmgren, 2001)**. When there is an imbalance between amino acid supply and use for protein synthesis (intake exceeding requirement), amino acid oxidation occurs, yielding ammonia, carbon dioxide and bicarbonate as the main end-products **(Kaushik and Cowey, 1991).** Rainbow trout, like most fish, is known to preferentially catabolise amino acids for energy use. But it is the deposition or accretion of protein (resulting in muscle mass gain) which determines amino acid requirement and supply in the diet **(Kaushik and Seiliez, 2010).** Understanding these dynamics not only contributes to improved aquaculture practices but also supports sustainable fish farming initiatives in hilly regions, ultimately leading to better economic outcomes for local communities and reduced environmental impacts. This study aims to provide valuable insights into the effective management of Rainbow trout aquaculture, paving the way for future research and development in this vital sector.

**2.0 Materials and Methods**

**2.1 Study Area**

The experiment was carried out at IF Farms' Rainbow trout Hatchery & Farm Complex, Lyngkienwar, adjacent to David Scott Trail, Nongrum Mawphlang - 793121, Meghalaya.

**2.2 Procurement of fish and acclimatization**

A total of 100 healthy and active Rainbow trout (*Oncorhynchus mykiss*) fingerlings were procured from the IF Farm and acclimatized for two weeks in properly well aerated tanks under controlled conditions. During the acclimatization period, the fish were monitored daily for health, behaviour, and environmental parameters such as temperature, dissolved oxygen and pH to ensure optimal adaptation to the experimental conditions prior to the commencement of the feeding trial.

**2.3 Collection of experimental fish feed**

Good quality fish feed was bought from the market through verified suppliers after careful evaluation of product specifications and supplier reliability. Upon arrival at the farm, the feed was thoroughly inspected to confirm that it met the agreed nutritional standards and showed no signs of contamination, spoilage or damage. Once verified, the feed was stored in designated, well-maintained storage facilities that ensured protection from moisture, pests and extreme temperatures. Feed of control (45% CP Nutrila-Growel), T1 (40% CP Nutrila-Growel), T2 (35% CP Aahar) and T3 (30% CP CIFA-CARP GROWER) were used as supplementary diets for different treatment tanks.

**2.4 Experimental Design and Setup**

The experiments had been set up based on Complete Randomized Design (CRD) with one control and three treatment groups and stocking density in each tank 10 fingerlings per tank. The tank dimensions was 183cm (L) x 61cm(W) x 30 cm(H) and a volume of 334.89 L installed with a pipe where the water flow is control from the collection tank to the treatment tank for maintenance of optimum dissolved oxygen was set up before introducing the fish for commencement of the experiments. An outlet was fitted to the upper treatment, where water was continuously flowing out from this treatment tank to the next tank. The experiment was set up in such a way that in the control group, the fingerlings were fed with feed containing standardized optimal protein and lipid composition. In the other three treatment groups, the fingerlings were fed varying protein and lipid compositions, as shown in Table 1. The fish were fed at a rate of 5% of their body weight per day, administered in two equal portions at 9:00 am and 5:00 pm throughout the study period of 120 days.

**2.5 Water Quality Parameters**

To maintain optimal water quality throughout the experimental period, water parameters such as dissolved oxygen (DO), pH, temperature, total alkalinity, total hardness, total ammonia and free carbon dioxide were monitored on a weekly basis.

**2.6 Growth parameters and survival rate**

The growth parameters were expressed as weight gain (g), percent weight gain (%) and specific growth rate (SGR) over the time of observation from the start of the experiment. The growth performance of the fish was assessed by using measuring parameters such as weight, length and specific growth rate (SGR). Based on the feed given and the fish's weight and length gain, parameters such as FCR, FER, and PER were further calculated.

1. Weight gain (g) = Final weight – Initial weight

2. Length gain (cm) = Final length – Initial length

3. Specific Growth Rate (SGR): $$SGR(\% day^{-1})= \frac{\left(Ln \left(final weight \right)-Ln \left(initial weight \right)\right)X 100}{Time intervals (days)}$$

4.Feed conversion ratio (FCR)

$$FCR= \frac{Feed intake (dry weight)g}{Body weight gain \left(wet gain\right)g}$$

5. Feed Efficiency Ratio (FER)

$$FER= \frac{Body weight gain \left(wet weight\right)g}{Feed intake \left(dry weight\right)g} $$

6. Protein Efficiency Ratio (PER)

$$PER=\frac{Body weight gain \left(wet weight\right)g}{Crude protein fed (g)}$$

7. Survival Rate (SR):

$$SR \left(\%\right)=\frac{No. of fish survived at the end of experimental day }{Number of fish stocked}X 100$$

**2.7 Analysis of Digestive Enzymes**

Amylase activity was estimated using the Dinitrosalicylic acid (DNS) method described by **(Rick and Stegbauler, 1974)** and absorbance was measured at 540 nm using spectrophotometer and expressed in millimoles. Protease activity was determined by the casein digestion method as outlined by **(Drapeau, 1974)**. Lipase activity was measured using the method developed by (**Cherry and Crandell,1932).**

**2.8 Statistical Analysis**

One-way ANOVA was followed by Tukey HSD’s multiple range test to determine differences between treatment means. All the statistical analysis was performed using SPSS (Version 25.0). The data were expressed as mean ± SE and differences were considered significant at *P < 0.05*.

**3.0 Results and Discussion**

**3.1 Physico-Chemical Parameters of Water**

Throughout the 120-days experimental period, water quality parameters remained stable across all the treatment tanks. Water temperature ranged from 13.5 ± 0.35 °C to 13.7 ± 0.3 °C, and pH values varied minimally, between 8.02 ± 0.05 and 8.16 ± 0.03. Dissolved oxygen levels were maintained between 5.99 ± 0.09 mg L⁻¹ and 6.10 ± 0.04 mg L⁻¹. Alkalinity ranged from 156.71 ± 3.65 mg L⁻¹ to 159.19 ± 3.06 mg L⁻¹, while hardness was recorded between 112.76 ± 2.71 mg L⁻¹ and 114.38 ± 3.40 mg L⁻¹. Total ammonia levels, measured prior to water exchange, ranged from 0.030 ± 0.002 mg L⁻¹ to 0.048 ± 0.001 mg L⁻¹. However, Free carbon dioxide remained negligible and below detectable limits throughout the study. Average values of all the treatments are presented in Table 2. Lower performance in feeds 2 and 3, with reduced protein and lipid content, suggests limited nutrient assimilation, likely due to decreased enzymatic activity and palatability. Water quality parameters—temperature, pH, dissolved oxygen—remained within optimal ranges for trout growth (**Boyd, 1998; Baird *et al*., 2004**), confirming that environmental conditions did not constrain performance.

**3.2 Growth Performance**

At the end of the experimental period, the control group exhibited the highest final body weight (235.6 ± 5.89 g) and body length (18.9 ± 0.22 cm), while the lowest values were recorded in the T3 group (141.36 ± 3.53 g and 15.9 ± 0.26 cm, respectively). The specific growth rate (SGR) was significantly greater in the control group (1.71 ± 0.03% day⁻¹) compared to the lowest value observed in T3 (1.19 ± 0.03% day⁻¹). Feed conversion ratio (FCR) was most favourable in the control group (0.96 ± 0.04), indicating better feed utilization efficiency, whereas T3 showed the least efficient FCR (1.83 ± 0.09). Similarly, the feed efficiency ratio (FER) and protein efficiency ratio (PER) were highest in the control group (1.042 ± 0.05 and 2.315 ± 0.09, respectively) and lowest in T3 (0.547 ± 0.04 and 1.821 ± 0.08), corresponding to the crude protein (CP) levels of 45% in the control diet and 30% in the T3 diet. Table 3 given below, presents the mean values obtained for all treatment groups. This study evaluated the growth performance of Rainbow trout (*Oncorhynchus mykiss*) fingerlings in Meghalaya using three commercially available diets with varying protein and lipid levels. Results clearly indicate that diet composition significantly affects growth and physiological responses. Feed 1 (45% CP, 18% lipid) yielded the highest final body weight (235.6 ± 5.89 g), specific growth rate (1.71 ± 0.03% day⁻¹), and lowest FCR (0.96 ± 0.04), reflecting superior feed utilization **Rashidian *et al.,* 2020**. These findings align with previous studies (**Ogunkoya *et al*., 2006; Boujard *et al*., 2004**) that highlight the benefits of high-protein, moderate-lipid diets in trout. Economic analysis from similar regions (**Kumar *et al*., 2021; Bolliet *et al.,* 2004.** Supports the use of high-quality diets, as increased feed cost is offset by improved growth and FCR. The favourable performance in this study confirms the suitability of Meghalaya’s hilly terrain for coldwater aquaculture. Compared with **Wani *et al.,* 2025**; **FAO (2013**) SGR benchmarks (1.2–1.8% day⁻¹), the results were promising, indicating efficient culture potential.

**3.3 Digestive Enzyme Analysis**

Amylase activity peaked in T1, which contained a moderate level of carbohydrates, but declined in lower-quality feeds, likely due to reduced feed intake or compromised gut health. Protease activity was highest in control and dropped significantly in the 35% and 30% crude protein (CP) feeds, possibly due to insufficient protein stimulus and reduced enzyme synthesis. Lipase activity generally reflected the dietary lipid content but also declined in less palatable feeds, potentially due to decreased metabolic engagement and overall poor feed utilization. While enzymatic assays were not conducted, literature suggests the superior growth in feed 1 may be linked to enhanced digestive enzyme activity, particularly protease and lipase (**Krogdahl & Bakke-McKellep, 2005; Hidalgo *et al*., 1999**). **Yadav *et al.,* 2023** also found similar findings in terms of protease, amylase and lipase. This likely improved nutrient absorption and metabolic efficiency in conclusion, the study demonstrates that both diet quality and regional environmental conditions in Meghalaya support efficient Rainbow trout aquaculture. These findings provide valuable baseline data for future research and commercial development in Northeast India.Top of Form

**Conclusion**

The research appropriately assessed the performance of growth in Rainbow trout (*Oncorhynchus mykiss)* fingerlings in Meghalaya's hilly area utilizing hetero-nitrogenous and hetero-lipidic commercially prepared feeds. The highest growth and feed efficiency were achieved with a high-protein (45 %), moderate-lipid (18 %) diet, which was an indication of enhanced nutrient assimilation, most likely facilitated by greater enzymatic activity (protease and lipase). Control produced the maximum SGR (1.71 ± 0.03 % day-1) and minimum FCR (0.96 ± 0.04), which means that this feed was metabolically superior for fingerlings of trout under the prevailing environmental conditions. The work emphasizes the relevance of species-specific diet formulation that considers nutritional requirements and points out that commercially obtainable feeds may prove effective as long as their protein and lipid contents are attuned to physiological and metabolic demand.

Overall, this study lays a solid groundwork for Rainbow trout culture in Meghalaya's hilly tracts on commercially formulated, nutritionally complete feeds. Future studies must investigate the long-term effects of the diets on body constitution, digestive enzyme profiles, economic acceptability, and compatibility for incorporation of local feed components to make the operation less dependent on external commercial feeds and more sustainable at the local level.

**Ethical Statement:**

In the present study, silver carp were collected from the School of School, Sanjeev Agrawal Global Educational (SAGE) University, and Bhopal India). Ethical approval, specimen collection, and maintenance were performed in strict agreement with all the recommendations India.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

**Disclaimer (Artificial Intelligence)**

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

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**Table1.** **Fish feed composition for different treatments**.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Control(C)** | **T1** | **T2** | **T3** |
| **Crude Protein (CP)** | 45.0 | 40.0 | 35.0 | 30.0 |
| **Crude Lipid (CP)** | 18.0 | 16.0 | 14.0 | 12.0 |
| **Ash** | 9.2 | 8.7 | 8.2 | 7.8 |
| **Moisture** | 10.5 | 10.0 | 9.5 | 9.0 |
| **Crude Fibre** | 3.5 | 3.9 | 4.3 | 4.7 |
| **Carbohydrate (NFE)** | 13.8 | 21.4 | 29.0 | 36.5 |

**Table 2. Physico-chemical parameters of different experimental groups**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TREATMENTS** | **C** | **T1** | **T2** | **T3** | ***p Value*** |
| **TAN (mgL-1)** | 0.030 ± 0.02 | 0.036 ± 0.01 | 0.036 ± 0.01 | 0.048 ± 0.01 | 0.001 |
| **DO (mgL-1)** | 5.99 ± 0.09 | 6.12 ± 0.01 | 6.22 ± 0.13 | 6.10 ± 0.04 | 0.3660 |
| **TA (mgL-1)** | 159.19 ± 3.06 | 160.14 ± 2.86 | 159.61 ± 3.46 | 156.71 ± 3.65 | 0.8830 |
| **TH (mgL-1)** | 114.38 ± 3.40 | 111.28 ± 1.64 | 110.23 ± 1.25 | 112.76 ± 2.71 | 0.6550 |
| **pH** | 8.16 ± 0.03 | 8.08 ± 0.04 | 8.08 ± 0.02 | 8.02 ±0.05 | 0.1170 |
| **Temperature (0C)** | 13 .5 ± 0.35 | 13.6 ± 0.35 | 13.3 ± 0.3 | 13.7 ± 0.3 | 0.8720 |
| **Free C02** | BDL | BDL | BDL | BDL | - |

Data is presented as mean ± SE. Means with different superscripts differ significantly in a row.

\*BDL, Below Detectable Levels

**Table 3. Effects of different feeding regimes for growth of Rainbow trout fingerlings**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **C** | **T1** | **T2** | **T3** |
| **In. weight (g)** | 30.45 ± 0.61 | 24.4 ± 0.49 | 28.9 ± 0.58 | 34.0 ± 0.68 |
| **Fn. weight (g)** | 235.6 ± 5.89 | 180.8 ± 4.52 | 176.7 ± 4.42 | 141.36 ± 3.53 |
| **In. length (cm)** | 13.79 ± 0.3 | 13.9 ± 0.19 | 13.49 ± 0.24 | 13.9 ± 0.21 |
| **Fn. Length (cm)** | 18.9 ± 0.22 | 17.01 ± 0.3 | 14.18 ± 0.19 | 15.9 ± 0.26 |
| **WG (g)** | 205.15 ± 4.1 | 156.4 ± 3.1 | 147.8 ± 2.9 | 107.36 ± 2.2 |
| **SGR (% day -1 )** | 1.71 ± 0.03 | 1.67 ± 0.03 | 1.51 ± 0.04 | 1.19 ± 0.03 |
| **FCR** | 0.96 ± 0.04 | 1.04 ± 0.05 | 1.33 ± 0.07 | 1.83 ± 0.09 |
| **FER** | 1.042 ± 0.05 | 0.961 ± 0.05 | 0.752 ± 0.06 | 0.547 ± 0.04 |
| **PER** | 2.315 ± 0.09 | 2.404 ± 0.10 | 2.148 ± 0.09 | 1.821 ± 0.08 |
| **Survival (%)** | 95 ± 0.04 | 90 ± 0.06 | 95 ± 0.04 | 85 ± 0.07 |

Data is presented as mean ± SE. Means with different significantly in a row.

**Table 4: Digestive enzymes activity**

|  |  |  |  |
| --- | --- | --- | --- |
| **Feed Type (CP/CL)** | **Amylase Activity (U/mg protein)** | **Protease Activity (U/mg protein)** | **Lipase Activity (ml NaOH/g tissue)** |
| **Control**  | 5.1 ± 0.3 | 9.3 ± 0.2 | 1.45 ± 0.05 |
| **T1**  | 5.4 ± 0.4 | 8.7 ± 0.3 | 1.40 ± 0.07 |
| **T2**  | 5.0 ± 0.6  | 6.8 ± 0.6  | 1.10 ± 0.12  |
| **T3**  | 4.7 ± 0.5  | 6.2 ± 0.8  | 0.95 ± 0.10  |

**Figure 1.** Weight gain (g) of different groups of Rainbow trout fingerlings

**Figure 2.** The FCR and SGR of different groups of Rainbow trout fingerlings

**Figure 3.** The FER and PER of different groups of Rainbow trout fingerlings