

Evaluating the effect of adding different levels of nano-silica to the diets of common carp (*Cyprinus carpio*) fingerlings and its impact on growth performance and feed conversion efficiency.

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Abstract

This study aimed to show the effect of adding different levels of silica nanoparticles to the diets of common carp (*Cyprinus carpio*) fingerlings on performance of growth and feed utilization efficiency. The experiment was conducted over sixty days using three dietary treatments: diets containing 32% raw protein protein and supplemented with three levels of silica nanoparticles (0, 2, and 4 mg/kg feed). Healthy fingerlings with an average initial weight of (25±5 g) were used and randomly dispersed into 6 identical tanks (two tanks per treatment) in a semi-closed aquatic system under a completely randomized design.

The results showed a significant enhancement ($P<0.05$) in growth indicators at the 2 mg/kg feed supplementation level. This treatment recorded the highest values for weight gain, specific growth rate, and feed utilization efficiency compared to the other treatments. As opposed to the highest level of nano-silica (4 mg/kg feed) resulted in decreased performance, suggesting that greater doses may have negative physiological effects that decrease feed utilization. Improved performance was also associated with a significant increase in the apparent protein digestibility coefficient at a level of 2 mg/kg feed. The study concludes that supplementing common carp diets with nano-silica at a level of 2 mg/kg feed represents the optimal level for improving growth and feed conversion efficiency without causing physiological stress.

Keywords: Nano-silica, common carp, growth, feed conversion efficiency, aquaculture.

I. Introduction

Rapid population growth is posing an increasing worldwide challenge to food security, especially considering the increased reliance on fish as a main source of animal protein. Water resources serve an important role in sustaining fish production and improving food supplies, making aquaculture one of the fastest-growing agricultural sectors globally. This is due to its major contribution to food security and long-term job creation, particularly in developing countries (FAO, 2020; Belton & Thilsted, 2014; Gui *et al.*, 2018).

Common carp (*Cyprinus carpio*) is an important species in global aquaculture due to its suitability for intensive farming, rapid growth, broad tolerance to environmental conditions, good response to artificial feeds, and ease of reproduction (Koehn *et al.*, 2000; Rahman, 2010; Coroian *et al.*, 2015; Song & Zhang, 2025). The most crucial economic element in aquaculture systems is feed, which accounts for a sizeable amount of overall production expenses and has a direct impact on fish health, growth efficiency, and water quality (Tacon & Metian, 2015; Taher & Al-Dubakel, 2020; Ahmed & Turchini, 2021). Growth rate is a key indicator for evaluating the efficiency of feed rations in common carp, as it directly reflects how well the fish benefit from the nutrients added to the feed (Fahad & Shuhaib, 2021).

Therefore, it is now essential to investigate modern feed additives that might enhance nutrient consumption and production performance.



In this regard, nanotechnology has emerged as a promising tool for developing aquaculture feeding systems. Nanomaterials have unique characteristics that enable them to improve feed conversion efficiency due to their small size and high specific surface area.

improve nutrient absorption. and activate certain essential functions (Farooq *et al.*, 2022; Fajardo *et al.*, 2022; Sharjeel *et al.*, 2024). Applications of nanotechnology in animal nutrition have shown that it can increase the efficiency of mineral usage by boosting solubility and absorption because of the small particle size, which has a good impact on microbial activity and digesting processes (Khashan & aL-Galiby, 2025).

Among these materials. silica nanoparticles have drawn more interest because of their physicochemical characteristics and relative biocompatibility. which make them suitable for use in fish and animal feed. When used in moderation, adding nano-silica can enhance digestibility. support digestive enzyme activity. and boost fish productivity. but going above the ideal level may have detrimental impacts on some physiological indicators. according to some research (Dube, 2024; Chughtai *et al.*, 2025; Rahman *et al.*, 2023).

Despite the increasing usage of nanomaterials in the industrial , agricultural, and medical fields, more research is still needed on the application of nano-silica in aquaculture, particularly with regard to determining the optimal degree of addition and its effects on the fish development and feed utilization efficiency. Thus, the purpose of this study was to assess how adding varying amounts of nano-silica to the diets of common carp fingerlings affected growth indices and feed utilization efficiency.

II. Materials and Methodes

2.1. Experimental Location

The study was carried out in the aquaponics unit of Thi Qar University's College of Agriculture and Marshes, which requires a semi-closed system, from October 20 to December 20, 2025. This unit was chosen for its potential for prolonged breeding studies because it provides a controlled environment in which the investment's productivity can be precisely measured.

2.2. Experimental Design

A Complete Random Design (CRD) was conducted with three different treatments and two replicates, resulting in a total of three experimental units. The fish tanks were randomly distributed across the treatments to reduce the impact of undesirable factors. The following were used to manage the plants:

(Control treatment) : Basic diet without nano-silica additive

T1 = Basic feed with added nano-silica at a level of 2 mg/kg of feed.

T2 = Basic feed with added nano silica at a level of 4 mg/kg of feed.

The fish were distributed at a rate of (50 fish per tank) so that the total number of fish used in the experiment was (300 fish).

2.3. Experimental Fish

In this study, common carp fingerlings (*Cyprinus carpio*) were used, with an average initial weight of 25 ± 5 grams. The fingerlings were obtained from a specialized and accredited hatchery in Babylon Governorate to ensure the fish's quality and genetic and environmental homogeneity as much as possible. The fish were transported to the aquaponics building of the College of Agriculture and Marshes using a vehicle equipped with a continuous oxygen supply system to minimize stress during transport and maintain a high survival rate. In order to allow the fingerlings to adjust to the new surroundings and guarantee their physiological stability before the experimental treatments and data collecting started. They were acclimated for ten days in the unit's tanks prior to the real experiment.



In order to maintain consistent nutritional conditions and avoid any potential impact on the fish's response before to the beginning of the experiment. The fish were fed a balanced commercial meal designed exclusively for fingerlings during this time., without any additional supplements. To be able to identify any early indications of stress or declining health, daily observations of the fish were made to evaluate their swimming behavior, motor response, feed intake rate, and adaption to the new habitat. To maintain stock homogeneity, assure the correctness of the experimental design, and reduce undesired variance in the final results, fingerlings that were weak, slow-growing, or clearly malformed were removed before being included to the experiment.

2.4. Experimental Conditions

To ensure water quality, each tank has internal mechanical filtration and a constant mechanical aeration system. Digital equipment that were calibrated before to usage were used to measure environmental parameters such as temperature, dissolved oxygen, and pH on a regular basis.

2.5. Preparation of Experimental Diets

The commercial ready-made feed ration utilized in this study was made by Arasco and contained 32% crude protein and 3000–3200 kcal/kg of metabolizable energy. As an addition, 99.5% pure nano-SiO₂ with a molecular size of 10–20 nm was utilized.

The following three feed treatments were made:

Control: Nano-silica-free basal ration.

T1: Basal ration + 2 mg nano-silica/kg feed.

T2: Basal ration + 4 mg nano-silica/kg feed.

The rations were made by combining 40 milliliters of pure water with the designated quantity of nano-silica, then spraying the suspension into the feed while continually stirring. After 30 minutes of room temperature drying, the meal was placed in airtight containers in a cold, dry location.

Table (1) shows the chemical analysis of the feed used in the experiment:

Nutritional	Composition (%)
Crude Protein	32
Diuretic Fat	8
Fiber	5
Maquis	9
Moisture	11
Carbohydrates	35
Energy	3200-3000

2.5. Feeding Program

The feeding program used in the feeding experiment for common carp fingerlings was created to minimize feed loss and maintain water quality while providing the nutrition required for growth. The fish were administered the experimental food bi-daily, once in the morning and once in the evening, adhering to a constant schedule.

This alleviated the stress associated with concurrent feeding and ensured an even distribution of nutrients. Daily, 5% of the fish's live body weight was administered, contingent upon their weight, age, and consumption rate. This feeding rate prevents the undesirable accumulation of organic matter in the ponds and is suitable for fingerlings of common carp.

To provide suitable nourishment and its alignment with physiological changes during the growth phase, the feed amounts were adjusted biweekly based on the fish's new updated weight.

In order to guarantee appropriate feeding and its compatibility for the physiological changes during the growth phase, the feed volumes were modified every two weeks depending on the fish's new average weight.

The amount of feed provided and the feeding time were recorded daily in the experiment logs. This helped in documenting the data and tracking any changes in food consumption during the study period.

2.6. Measurements Under Study

The measurements included:

Initial weight of the fish

Biweekly weight gain

Weight gain

Daily growth rate (DWG)

Total growth rate

2.7. Statistical Analysis

Completely randomized design (CRD) was used for statistical analysis of one factor with three treatments. Significance of differences between means was tested using the Revised Least Significant Differences (RLSD) method with the SPSS statistical software (2021) (V.26).

$$Y_{ij} = \mu + T_i + E_{ij}$$

Y_{ij} = Value of observations j in treatment i

μ = Overall mean

T_i = Effect of treatment i

E_{ij} = Effect of experimental error inherent in observation j on a mean of zero and a variance



III. Results and Discussion

3.1. Effect of Nano-silica on Fish Weight

The results in **Table (2)** show no significant differences between the experimental treatments during the first two weeks of the study. This indicates that the addition of nano-silica did not have a direct and rapid effect on fish weights in the early stages of the experiment. This can be explained by the fact that the physiological effects of nanomaterials require sufficient time to be reflected in digestion, absorption, and metabolism, and consequently, in growth.

Furthermore, the similarity in the initial fish weights across the different treatments led to a decrease in the variability between the groups at the beginning of the study, thus limiting the emergence of early significant differences. This result is consistent with the findings of **Owais *et al.* (2025)**, who claimed that the effect of nano-silica on digestive enzymes and growth performance is gradual and related to the duration of feeding. In the beginning, statistical variance is not as apparent because of the uniformity in the initial weights.

The outcome is also consistent with study on Nile tilapia conducted by **Bashar *et al.* (2021)**, who observed that the physiological impacts of nano-silica in the digestive tract take time to interact with living tissues and activate metabolic processes.

Treatment T1 surpassed treatment T2 during the fourth week, yet no significant difference was observed compared to the control treatment. This indicates that the small amount of nano-silica added is beginning to show positive impact, however this impact was not sufficient to differentiate among all treatments.

This effect became increasingly evident throughout the sixth and eighth weeks, when treatment T1 surpassed both the control and T2 treatments. This suggests that the optimal quantity for enhancing growth and improving feed utilization efficiency is 2 mg/kg of feed. This is explained by nano-silica's capacity to enhance the digestive environment and boost the effectiveness of nutrient absorption. This is because the high specific surface area and small particle size improve the utilization of feed components and boost the activity of digestive enzymes.

A cumulative physiological reaction to nano-silica is reflected in the improvement in ultimate fish weight in treatment T1. Better absorption and digestion don't immediately result in weight gain; instead, they need a long enough feeding period to show up in body growth. This explains why differences were not noticeable early on in the experiment but grew more noticeable later on.

Table (2). Impact of nano-silica addition on common carp fish weights (g) over the course of the experiment (Mean \pm Standard Error)

Treatments	Week 0	Week 2	Week 4	Week 6	Week 8
Control	4.11 \pm 28.445	31.86 3.31 \pm 2	\pm 45.95 6.40ab	65.663 3.86 \pm b	\pm 87.810 8.80b
T1	27.77 6.74 \pm 1	32.15 3.87 \pm 0	3.86 \pm 55.09a	79.361 6.08 \pm a	\pm 116.00 12.99a
T2	5.782 \pm 29.950	4.51 \pm 0.244	\pm 45.19 2.90b	6.25 \pm 59.443b	\pm 78.563 5.90b
Significance	NS	NS	0.05	0.05	0.05

N.S. indicates that the mean scores do not differ significantly. T1: Additive-free control treatment. control treatment (no chemicals).

T1: Second treatment (2 mg/kg nano-silica).

T2: Third treatment (4 mg/kg nano-silica).

3-2 Effect of Nano-Silica on Weight Gain and Feed Utilization Efficiency

With values of 88.23, 59.37, and 48.61, respectively, **Table (3)** demonstrates substantial differences in total weight gain favoring the second treatment over the control and third treatments. The cumulative daily weight gain during the raising period is directly reflected in the results, which show the superiority of the second treatment (T1). A higher final weight was the result of this everyday improvement.

These findings align with the research conducted by **Aslam et al. (2024)**, which shown that the addition of nano-silica to fish diets resulted in a considerable increase in final weight because it improved metabolic efficiency. Additionally, the study by **Das et al. (2025)** showed that using nano-silica improved the tilapia fish's overall weight.

However, this study is different from that of **El-Sayed et al. (2021)**, who showed that the use of high concentrations of nano-silica caused a reduction in overall development because of toxic effects and accumulation inside tissues, which explains the decreased performance in the third treatment (T2).

Regarding daily weight gain, the second treatment (T1) also outperformed the control and third treatment (T2), with values of 1.47, 0.99, and 0.81, respectively.

Daily weight gain is a sensitive indicator that directly reflects the efficiency of physiological and digestive processes. The results showed the superiority of the second treatment (T1), indicating that the fish were able to utilize the feed continuously and effectively. This can be explained by the fact that nano-silica improves intestinal absorption efficiency, enhances digestive enzyme activity, and contributes to improving the intestinal microbial environment. This aligns with the findings of **Aslam et al. (2024)**, who confirmed that incorporating nano-silica contributes to increased digestive and metabolic efficiency, which positively impacts daily growth rates. This explains the remarkable superiority of the second treatment (T1).

This result also differs from that of **Rashidian et al. (2023)**, whose findings in **Table (3)** indicated a statistically significant advantage ($P < 0.05$) in the average daily weight gain in favor of the second treatment (T1), which reached (1.47 g/day), compared to the control group (0.99) and the third treatment (T2) (0.81 g/day). This contradicts **El-Sayed's (2021)** findings, as his study did not record a similar improvement, or perhaps even lower daily growth rates when using similar concentration of nano-silica.

Regarding feed conversion efficiency, the second treatment also outperformed the control and third treatments, with values of 4.41, 2.43, and 1.97, respectively.

These results showed a significant improvement in feed conversion efficiency in the second treatment (T1), indicating that the fish were able to convert a smaller amount of feed into live weight. This is an important indicator of weight gain and fish production. This phenomenon can be attributed to the enhancement of metabolic efficiency, reduction of feed loss, and improvement in digestion and nutrient utilization facilitated by Nano- silica.

The results correspond with the study by **Bashar et al. (2021)**, which demonstrated that the incorporation of nano-silica into fish diets enhanced feed conversion efficiency. Furthermore **Abdel-Latif et al. (2025)**, assert that nano-silica enhanced nutrient absorption, hence increasing feed utilization efficiency. Conversely the use of nano-silica did not markedly enhanced feed conversion efficiency, as reported by **Murshed et al. (2023)**. This is elucidated by variations in fish species and the concentration employed, indicating that the effect my fluctuate depending on the experimental configuration.

Table (3) indicates significant differences ($P < 0.05$) in total weight increase with values of 88.23, 59.37, and 48.61 g, respectively, favoring the second treatment (T1) compared to the control and third treatments (T2). This advantage is demonstrated by the cumulative gain throughout the growing phase, leading to an increased weight. This demonstrate that fish treated with nano-silica at the concentration utilized in (T1) performed better in terms of production.

These results are consistent with those of **Aslam et al. (2024)**, who discovered that adding nano-silica to fish meal leads to a significant increase in final weight due to improved metabolic efficiency. A study by **Das et al. (2025)**, which discovered that using nano-silica improved the tilapia fish's overall weight, sported these findings. These result, however, contradicted those of **El-Sayed et al. (2021)**, who suggested that the use of high concentrations of nano-silica may result in decreased growth due to toxic effects and accumulation in tissues, which could account for the third treatment's (T2) worse performance.

The second treatment (T1) significantly surpass the control and (T2) treatments in daily weight increase, with values of 1.47, 0.99, and 0.81 g/day, respectively. The superiority of T1 illustrates the fish's ability to consistently and efficiently utilize feed, while daily weight gain serves as sensitive measure of the efficacy of physiological and digestive processes. This phenomenon can be elucidated by the manner in which nano-silica promotes microbial equilibrium in the gastrointestinal tract, augments the activity of digestive enzymes, and raises the efficiency of the intestinal absorption.

These results are consistent with those of **Aslam et al. (2024)**, who reported that the use of nano-silica contributes to enhanced digestive and metabolic efficiency, positively impacting daily growth rates. However, they differ from the findings of **Rashidian et al. (2023)** and **El-Sayed et al. (2021)**, whose studies did not record a similar improvement in daily growth rates, possibly due to differences in the concentrations used or the experimental conditions.

Regarding feed conversion efficiency, the second treatment (T1) showed a significant advantage over the control and T2 treatments, with values of 4.41, 2.43, and 1.97, respectively.

Table (3) shows the effect of using nano silica on total and daily weight gain and food conversion efficiency (mean \pm standard error)

Treatments	Total weight gain	daily weight gain	Food conversion efficiency
Control	$\pm 59.3711.09$ b	0.99 ± 0.18 b	1.97 ± 0.51 b
T1	88.23 ± 11.3 a	1.47 ± 0.25 a	4.41 ± 0.76 a
T2	48.61 ± 6.92 b	0.81 ± 0.12 b	2.43 ± 0.35 b
Significance	0.05	0.05	0.05

Different letters indicate significant differences between the mean scores of the treatments under a significant effect ($P < 0.05$):

Control treatment (no additive)

T1: Second treatment (2 mg/kg nano-silica)

T2: Third treatment (4 mg/kg nano-silica).

IV. Conclusion

The study concludes that adding nano-silica to the diets of common carp fingerlings affects weight gain depending on the level of addition. No significant differences were observed in the initial stages of the experiment. However, the medium level of nano-silica (2 mg/kg feed) achieved the best performance in the later stages, significantly outperforming both the control treatment and the treatment with the highest concentration. These results indicate that the medium level represents the optimal dosage for improving growth, while increasing the concentration to 4 mg/kg may lead to a decrease in production efficiency.

V. Recommendations

The use of nano-silica at a level of 2 mg/kg of feed in common carp fingerling diets is recommended to improve production performance. Further studies are also recommended to evaluate the effect of this

substance on hematological, immunological, and digestive characteristics, as well as to investigate its long-term effects on water quality and fish health.

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