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The Impact of Dietary Vitamin Supplementation (B-Complex, C, D, and E) on Growth Performance and Survival of Freshwater Fish: A Systematic Review

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Abstract

This study aims to analyze the effects of dietary supplementation with B-complex vitamins C, D, and E on the growth performance and survival rate of freshwater fish. The systematic literature review examined various scientific articles published between 2016 and 2026, focusing on commonly farmed freshwater fish species such as tilapia, catfish, pangasius, and carp. The findings indicate that vitamin supplementation positively influences growth performance, feed efficiency, and the immune system of fish, thereby contributing to improved survival. Specifically, B-complex vitamins enhance metabolism and growth, vitamin C promotes growth and immune function, vitamin E acts as an antioxidant supporting cell health and reproduction, and vitamin D aids in tissue formation and body quality. Optimal results are achieved when vitamin inclusion is tailored to the specific fish species and aquaculture objectives.

Keywords: fish feed, freshwater fish, growth, nutrition, survival, vitamins

I. INTRODUCTION

The aquaculture sector is a crucial global food source, with its contribution to total fisheries production steadily increasing to meet the rising demand for animal protein, as noted by the Food and Agriculture Organization of the United Nations (FAO). This global trend is mirrored in Indonesia, which boasts extensive aquatic resources and a thriving freshwater fish farming industry. The potential area for freshwater aquaculture in Indonesia is estimated at approximately 2.83 million hectares, presenting significant opportunities to boost national production (KKP 2024). In 2023, the national production of major freshwater fish commodities, including tilapia, catfish, pangasius, and carp, reached approximately 3.49 million tons, representing a steady increase from previous years and underscoring the strategic role of sector in national food security and economic welfare (Ministry of Marine Affairs and Fisheries).

Freshwater aquaculture in Indonesia is dominated by economically valuable commodities such as tilapia (*Oreochromis niloticus*), catfish (*Clarias* sp.), pangasius (*Pangasius pangasius*), and common carp (*Cyprinus carpio*). Regional statistics highlight their prominence: for instance, the South Sumatra Provincial Marine and Fisheries Agency reported that in 2022, aquaculture production totaled 85,960,472 kg of catfish, 77,756,502 kg of pangasius, 47,557,926 kg of tilapia, and 9,550,601 kg of common carp (Marine and Fisheries Agency of South Sumatra Province 2022). This sustained high production is closely tied to various supporting factors, most notably the quality of feed. Feed is a critical component of aquaculture operations as it directly influences growth rates, survival rates, and production efficiency. Notably, feed costs often account 60–70% of total production

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expenses, making effective feed management vital for improving productivity and profitability (Halija *et al*. 2019). The nutritional content of feed, consisting of protein, fats, carbohydrates, minerals, and vitamins, is essential for supporting fish metabolism and growth. Vitamins, as micronutrients, are critical for metabolic processes, immune system enhancement, and overall development. Since fish cannot optimally synthesize certain vitamins endogenously, dietary supplementation is necessary. Deficiencies can lead to growth disorders, weakened immunity, and increased mortality rates (Rioeh *et al*. 2023). Numerous studies have explored these effects; for example, research on tilapia fingerlings demonstrated that a 3% vitamin mix in feed resulted in a significant increase in length of 5.77 cm and an 86.67% survival rate (Mutia *et al*. 2019). Similarly, vitamin E supplementation (100–200 mg kg^{-1} of feed) has been shown to improve physiological condition and reproductive performance in female tilapia (Hartandi *et al*. 2022).

In Despite the established roles of vitamins, comparative studies on the effectiveness of B-complex, C, D, and E across various freshwater fish species remain limited. Given the physiological and nutritional differences among species, understanding optimal dosages is crucial for enhancing feed efficiency and global aquaculture productivity. Therefore, this study aims to systematically evaluate the growth and survival responses of tilapia, catfish, pangasius, and carp to supplementation with various vitamins through a literature review.

II. MATERIALS AND METHODS

This study employed a Systematic Literature Review (SLR) method, using secondary data from peer-reviewed scientific journal articles. The review examined and analyze research findings on the effects of specific vitamin supplementation on the growth performance and survival rate of freshwater fish. The subjects of this research included four commonly farmed species: Nile tilapia (*Oreochromis niloticus*), catfish (*Clarias* sp.), pangasius (*Pangasius pangasius*), and common carp (*Cyprinus carpio*). The vitamins analyzed were B-complex, C, D, and E, which were integrated into the fish feed formulations.

Data collection was performed by reviewing relevant scientific articles through various academic databases and search engines, including Publish or Perish, Google Scholar, OpenAlex, Scopus, and Open Knowledge Maps. The search strategy utilized specific keywords such as "vitamin supplementation in fish feed," "fish nutrition," "growth performance of freshwater fish," "survival rate of freshwater fish," "vitamin B complex," "vitamin C," "vitamin D," and "vitamin E in aquaculture." The literature sources were limited to articles published between 2016 and 2026 to ensure that the findings represented the latest advancements in fish nutrition and aquaculture technology.

2.1 Inclusion and Exclusion Criteria

The The inclusion criteria for this study encompassed articles published in reputable national or international scientific journals available in full text. Selected articles were required to discuss the administration of vitamin B complex, C, D, or E in fish feed and specifically focus on the growth and survival of the four target species. Furthermore, articles were mandatory to provide quantitative data on growth performance (such as Specific Growth Rate/SGR) and Survival Rate (SR).

Conversely, exclusion criteria were applied to articles unrelated to vitamins in fish feed, studies not involving the specified fish species, and publications other than peer-reviewed journal articles, such as books or non-refereed reports. Articles were also excluded if the vitamins were combined with other experimental substances that could confound the results, or if they only measured physiological/immune parameters without providing corresponding growth or survival data

2.2 Literature Selection Process

Broodstock The literature selection process involved three primary stages: identification, screening, and inclusion. During the identification stage, an initial search was conducted across databases using predetermined keywords. Subsequently, the identified articles were collected and deduplicated. In the screening stage, titles and abstracts were reviewed to assess relevance, and irrelevant studies were eliminated. Finally, the remaining articles underwent a full-text review to ensure they met all established inclusion criteria. This systematic process is visually represented in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram in Figure 1.

2.3 Data Extraction and Analysis

The Data extraction was conducted by identifying key information from each selected article, including the name of author, publication year, fish species, vitamin type, dosage, feeding duration, and fish age. The extracted data were then systematically organized into tables to facilitate a descriptive comparative analysis. This analysis evaluated the effects of vitamin supplementation on the growth and survival of tilapia, catfish, pangasius, and carp, providing a comprehensive overview of the role of micronutrients in enhancing freshwater aquaculture productivity.

III. RESULT AND DISCUSSION

3.1 Vitamin B Complex

Broodstock Vitamin B complex is an essential nutrient that plays a critical role in energy metabolism, growth, and endurance in fish. Feed supplementation has been shown to improve growth performance and survival, although optimal dosages vary significantly by species. It is important to note that the specific composition of the B-complex used can vary across studies, potentially influencing the observed outcomes. A summary of the effects of Vitamin B Complex supplementation is presented in Table 1.

Table 1. Summary of the effects of Vitamin B Complex supplementation on the growth performance and survival rate of various freshwater fish species.

Based on the data in Table 1, vitamin B complex administration has been shown to positively affect the growth performance of several cultured fish species. This is indicated by improvements in key growth parameters, including absolute weight and specific growth rate (SGR), following dietary supplementation with vitamin B complex at different doses.

Dumbo catfish fed vitamin B complex at a dose of 140 mg kg^{-1} feed produced the highest absolute weight gain of 10.52 g (Rahman *et al*. 2025). Likewise, tilapia fed 20 mg kg^{-1} showed a significant increase in growth rate and achieved a survival rate of 94% (Fadilah *et al*. 2020). These findings indicate that different fish species require different levels of vitamin B complex to support optimal growth, depending on their physiological characteristics and metabolic requirements.

Pangasius supplemented with liquid vitamin B complex at a dose of 10 mL kg^{-1} feed also exhibited an absolute weight gain of 5.27 g and achieved a 100% survival rate (Nuha *et al*. 2019). Meanwhile, common carp supplemented with 7 mg kg^{-1} feed showed the highest specific growth rate (SGR) in Treatment 7, although no significant difference in survival rate was reported among treatments (Sharifzade *et al*. 2015). These differences in dosage and formulation suggest that the effectiveness of vitamin B complex is influenced not only by fish species but also by the form and concentration of supplementation.

Vitamin B complex functions as an essential coenzyme in carbohydrate, protein, and lipid metabolism, thereby improving nutrient utilization and feed efficiency. Enhanced metabolic activity enables fish to convert nutrients more efficiently into body tissue, leading to improved growth performance. Furthermore, adequate vitamin B complex supplementation may help maintain physiological condition of fish and increase.

Their tolerance to environmental stress, thereby contributing to higher survival rates. Therefore, dietary supplementation of vitamin B complex can be considered an effective nutritional strategy to improve aquaculture productivity, provided that the dosage is adjusted according to the nutritional requirements of each fish species.

3.2 Vitamin C

Vitamin C supplementation in feed has been shown to affect the growth performance and survival of several freshwater cultured fish species. The results analyzed in this study indicate that administering vitamin C at specific doses can increase growth and nutrient utilization efficiency in tilapia, catfish, carp, and pangasius. A summary of the research results regarding the vitamin C doses tested, the optimal dose, and the observed parameters is presented in Table 2.

Table 1. Summary of the effects of Vitamin B Complex supplementation on the growth performance and survival rate of various freshwater fish species.

Fish Species	Optimal Dose	Key Parameters	Results	SR (%)	Source
Dumbo Catfish	40 mg kg^{1}	Absolute Weight	10,52 g	-	Rahman *et al*. 2025
Tilapia	20 mg kg^{-1}	Growth Rate	Significantly Increased	94	Amel *et al*. 2020
Pangasius	10 mL kg^{-1}	Absolute Weight	5,27 g	100	Nuha *et al*. 2019
Common Carp	7 mg kg^{-1}	Specific Growth Rate	Treatment 7	-	Sharifzadeh *et al*. 2016

Table 2. Summary of the effects of Vitamin C supplementation on the growth performance and survival rate of various freshwater fish species.

Fish Species	Optimal Dose	Key Parameters	Results	Source
Nile tilapia (*O. niloticus*)	Vit. C 1000 mg kg^{-1} + probiotics 10^7 CFU mL^{-1}	TKP, EPP, FCR, PER, RGR, SR	Best: FCR 1.55; SR >90%	Pangestyastuti *et al.* (2017)
Catfish (*Clarias* sp.)	893 mg kg^{-1}; best SR at 750 mg kg^{-1}	SR, antibody titer, liver vit. C	Best SR 96%; predicted optimum 98.86%	Taukhid *et al.* (2006)
Common carp (*C. carpio*)	750 mg kg^{-1} feed	SR	Highest SR: 82.22%	Taukhid & Lusiastuti (2010)
Pangasius (*P. pangasius*)	100 mg L^{-1} Artemia enrichment	SR, length, weight	Best SR 76.17%; TL 1.63 cm	Setiawati *et al.* (2013)

Table 2. Summary of the effects of Vitamin C supplementation on the growth performance and survival rate of various freshwater fish species.

Vitamin C is an essential micronutrient that plays an important role in fish growth, survival, immunity, and feed utilization. Based on the four studies you provided, vitamin C showed positive effects both when used alone and when combined with probiotics. In general, the best results were obtained at the optimum dose, while excessive doses could reduce performance. In the study by Setiawati *et al*. (2013), Artemia enriched with vitamin C at a dose of 100 mg L^{-1} in the enrichment medium produced the best results for Pangasius pangasius larvae. Survival rate reached 76.17 ± 12.78%, total length was 1.63 ± 0.34 cm, and individual weight was 20.60 ± 3.80 mg. These values were higher than those of the control group and the 150 mg L^{-1} treatment. This result indicates that the vitamin C requirement of the larvae was optimally met at 100 mg L^{-1}. Vitamin C acts as an antioxidant, supports collagen synthesis, helps calcium absorption, and reduces stress in fish. In contrast, the 150 mg L^{-1} dose was assumed to be excessive and may have caused hypervitaminosis, which reduced larval performance.

In *Cyprinus carpio*, Taukhid and Lusiastuti (2010) reported that supplementation with microencapsulated vitamin C (CFC-90) at 750 mg kg^{-1} feed resulted in the highest survival rate, reaching 82.22% after KHV challenge. This value was higher than those of the 250 mg kg^{-1}, 500 mg kg^{-1}, 1,000 mg kg^{-1}, and control treatments. The result shows that vitamin C can improve fish health status and non-specific immunity, making fish more resistant to infection. The mechanism involves activation of cell-mediated immunity, increased phagocytic activity, and support for lymphocyte and antibody formation. Therefore, 750 mg kg^{-1} was identified as the optimal dose to improve resistance in common carp

In *Oreochromis niloticus*, the combination of vitamin C at 1,000 mg kg^{-1} feed and probiotics at 10^7 CFU mL^{-1} (treatment A2B3) gave the best results in feed efficiency and growth performance. This treatment produced the highest feed consumption, feed efficiency, protein efficiency ratio, and relative growth rate, while the feed conversion ratio was the lowest among all treatments. Although the survival rate was above 90% accros all groups and showed no significant differences, this combination was highly effective in improving feed utilization. Vitamin C supports normal growth, prevents skeletal deformities, speeds up wound healing, and improves disease resistance. Probiotics help suppress pathogenic bacteria in the digestive tract, improve nutrient digestibility, and optimize enzyme activity, which leads to better biomass gain.

In *Clarias* sp., Taukhid *et al*. (2006) found that vitamin C CVC F-90 at 750 mg kg^{-1} feed gave the highest survival rate of 96.00% after challenge with *Aeromonas hydrophila*. Based on quadratic regression analysis, the optimal dose for the highest survival rate was 893 mg kg^{-1} feed, with a predicted survival rate of 98.86%. This result indicates that catfish require a relatively high level of vitamin C to improve resistance against bacterial infection. The vitamin C content in the liver also increased with increasing as the dietary dose, indicating that the vitamin was absorbed and stored in the body. Vitamin C functions as a coenzyme, antioxidant, and immune modulator that supports phagocyte activity and specific antibody production.

Overall, the four studies show that vitamin C plays an important role in supporting fish production performance, especially in growth, feed efficiency, and survival. The optimum dose depends on the fish species and culture conditions, so vitamin C should be adjusted according to the biological needs of each species. In some cases, combining vitamin C with probiotics can produce better results than using vitamin C alone.

These findings confirm that vitamin C is an important nutrient in fish feed formulation to improve aquaculture productivity

3.3 Vitamin E

Larvae The inclusion of vitamin E in fish feed formulations plays an important role as a biological antioxidant, protecting cell membrane integrity against oxidative damage. This function contributes to improved physiological performance, feed utilization, and survival in cultured fish. However, the effectiveness of vitamin E supplementation varies by fish species, dosage, and combination with other dietary supplements. A summary of the effects of vitamin E supplementation on the growth performance and survival rate of several freshwater fish species is presented in Table 3.

Table 3. Summary of the effects of Vitamin E supplementation on the growth performance and survival rate of various freshwater fish species.

In Nile tilapia (*Oreochromis niloticus*), dietary supplementation with 100 mg vitamin E kg^{-1} diet produced the most favorable growth performance (Rohani *et al*. 2023). Fish fed this diet reached a final body weight of 22.61 ± 1.58 g and gained of 19.05 ± 1.67 g. The specific growth rate (SGR) reached 1.43 ± 0.16% day^{-1}, while the protein efficiency ratio (PER) increased to 2.40 ± 0.27. In addition, the feed conversion ratio (FCR) decreased to 1.09 ± 0.08, indicating more efficient feed utilization, and the survival rate remained high at 99%. These results demonstrate that an appropriate level of vitamin E supplementation can simultaneously enhance growth performance, feed efficiency, and fish survival.

In striped catfish (*Pangasius pangasius*), the combination of vitamin E (200 mL kg^{-1}) and *Moringa oleifera* leaf extract (150 mL kg^{-1}) resulted in the highest survival rate of 95 ± 5.03%, compared with 92 ± 4.62% in the control treatment (Fadhillah *et al*. 2023). This finding suggests that combining vitamin E with natural plant-based supplements may provide additional benefits for maintaining fish survival during the culture period.

Similarly, dietary supplementation with 500 mg vitamin E kg^{-1} in catfish (*Clarias* sp.) improved survival performance, with the survival rate increasing to 76.6 ± 4.71%, compared with 60.0 ± 8.16% in the control group (Sembiring *et al*. 2024). These findings indicate that vitamin E supplementation can improved fish survival under culture conditions

In common carp (*Cyprinus carpio*), supplementation with 100 mg vitamin E and 20 mg vitamin B2 kg^{-1} diet improved feed efficiency and daily growth. However, no significant differences in survival rate were observed among treatments (Sharifzadeh *et al*. 2015). This result indicates that although the combination of vitamin E and vitamin B2 supports growth-related performance, its effect on survival may depend on species-specific responses and culture conditions.

Overall, the studies summarized in Table 3 demonstrate that vitamin E supplementation improves aquaculture performance, particularly by enhancing growth, feed utilization, and survival. Nevertheless, the magnitude of these effects varies among fish species and with whether vitamin E is administered alone or in combination with other dietary supplements, highlighting the importance of optimizing supplementation strategies for different aquaculture species.

3.4 Vitamin D

The The inclusion of vitamin D in fish feed formulations plays a crucial role in regulating calcium and phosphorus metabolism, thereby supporting

Fish Species	Optimal Dose	Key Parameters	Results	Source
Nile tilapia (*O. niloticus*)	Vit. E 100 mg kg^{-1} diet	WG, SGR, FCR, PER, SR	Improved growth and feed efficiency; SR 99%	Rohani *et al.* (2023)
Catfish (*Clarias* sp.)	Vit. E 500 mg kg^{-1} diet	SR	SR increased to 76.6%	Sembiring *et al.* (2024)
Common carp (*C. carpio*)	Vit. E 100 mg + Vit. B2 20 mg kg^{-1}	Growth, SR	Improved growth; SR not significantly different	Sharifzadeh *et al.* (2015)
Pangasius (*P. pangasius*)	Vit. E 200 mL kg^{-1} + moringa extract 150 mL kg^{-1}	SR	Highest SR: 95 ± 5.03%	Fadhillah *et al.* (2023)

Table 4. Summary of the effects of Vitamin D on the growth performance and survival rate of various freshwater fish species.

Fish Species	Optimal Dose	Key Parameters	Results	Source
Nile tilapia (*O. niloticus*)	3% of total feed	Growth, SR	Length gain 5.77 cm; weight gain 19.48 g; SR 86.67%	Mutia *et al.* (2019)
Catfish (*Clarias* sp.)	100 mg kg^{-1} feed	WG, LG, SGR, SR, EPP	Weight gain 6.10 g; length gain 13.81 cm; best intestinal villi development	Angeline (2025)
Grass carp (*C. idella*)	Vit. D 1,167.9 IU kg^{-1} feed	Meat quality, antioxidant capacity, muscle development	Improved protein, collagen, and antioxidant capacity	Zhang *et al.* (2020)
Pangasius (*P. pangasius*)	Probiotic multivitamin 10 mg kg^{-1} feed	Growth, SR	Weight gain 5.72 g; length gain 5.72 cm; SR 100%	Nuha *et al.* (2019)

skeletal development, mineral homeostasis, and overall physiological functions. Dietary vitamin D supplementation has been reported to improve growth performance, feed utilization efficiency, and survival in various fish species by enhancing nutrient absorption and promoting proper bone formation. In addition, adequate vitamin D levels contribute to immune modulation and metabolic regulation, enabling fish to better withstand environmental stress and disease challenges during culture. The effectiveness of vitamin D supplementation varies depending on fish species, developmental stage, and dietary dosage. Based on data from several case studies, the effective doses and biological responses to vitamin D supplementation in different fish species are summarized across Table 4.

Vitamin D is an essential micronutrient that plays a fundamental role in calcium and phosphorus metabolism, skeletal development, nutrient absorption, and physiological regulation in fish. Based on the studies summarized in Table 4, dietary vitamin D supplementation has been shown to improve growth performance, survival rate, and body quality in several freshwater fish species. However, the optimal dosage and biological responses vary with the fish species, developmental stage, and feeding strategy.

In grass carp (*Ctenopharyngodon idella*), dietary supplementation with 1,167.9 IU kg^{-1} vitamin D significantly improved meat quality by increasing crude protein, amino acid, and collagen contents, while reducing cooking loss and enhancing antioxidant enzyme activities (Zhang *et al*. 2020). These findings indicate that vitamin D not only contributes to skeletal mineralization but also improves muscle development and meat quality by enhancing protein metabolism and antioxidant capacity. Consequently, vitamin D supplementation may increase the nutritional value and market quality of cultured grass carp.

In pangasius (*Pangasius pangasius*), supplementation with 10 mg kg^{-1} probiotic multivitamin resulted in an absolute weight gain of 5.72 g, an absolute length increase of 5.72 cm, and a survival rate of 100% (Nuha *et al*. 2019). The combination of vitamin D with other vitamins and probiotics likely enhanced nutrient digestibility and intestinal microbial balance, thereby improving feed utilization efficiency and supporting optimal growth and survival. This result demonstrates that multivitamin supplementation can effectively improve production performance in pangasius culture.

Similarly, Nile tilapia (*Oreochromis niloticus*) fed a diet containing 3% vitamin mix exhibited increase in absolute length of 5.77 cm, an increase in absolute weight of 19.48 g, and a survival rate of 86.67% (Mutia *et al*. 2019). These findings suggest that adequate vitamin supplementation supports metabolic processes involved in tissue formation and growth while maintaining fish health throughout the culture period. Although the study used a vitamin mixture rather than vitamin D alone, the results indicate that dietary vitamin supplementation contributes positively to fish growth and survival.

In catfish (*Clarias* sp.), dietary supplementation with 100 mg kg^{-1} vitamin D produced the highest growth performance, including a weight gain of 6.10 ± 0.16 g, a length gain of 13.81 ± 0.33 cm, a daily weight gain of 0.10 ± 0.003 g day^{-1}, and a daily length gain of 0.23 ± 0.005 cm day^{-1} (Angeline 2025). Furthermore, fish receiving this treatment exhibited the greatest intestinal development, characterized by 34 intestinal villi with a total villus surface area of 854.522 μm^2. Improved intestinal morphology increases the absorptive

surface area available for nutrient uptake, thereby enhancing feed utilization efficiency and promoting faster growth. These findings demonstrate that vitamin D supplementation not only supports skeletal development but also improves digestive function and overall physiological performance in catfish.

Overall, the available evidence suggests that vitamin D supplementation plays an important role in improving freshwater fish production by enhancing growth performance, nutrient utilization, intestinal development, flesh quality, and survival. Nevertheless, the optimum dosage varies among fish species and production objectives. Therefore, dietary vitamin D supplementation should be adjusted according to species-specific nutritional requirements to maximize growth performance, feed efficiency, and aquaculture productivity.

IV. CONCLUSION

This systematic literature review demonstrates that dietary vitamin supplementation is an effective nutritional strategy to improve the productivity of freshwater aquaculture. Overall, supplementation with vitamins B-complex, C, D, and E positively affects fish growth performance, feed utilization, immune response, and survival rate, although the magnitude of these effects varies depending on fish species, developmental stage, dietary dosage, and culture conditions.

Among the vitamins reviewed, vitamin B-complex primarily supports energy metabolism and nutrient utilization; vitamin C enhances antioxidant capacity and disease resistance; vitamin E protects cellular integrity against oxidative stress while improving physiological performance; and vitamin D contributes to calcium metabolism, skeletal development, and nutrient absorption. Several studies also demonstrated that combining vitamins with natural additives or probiotics produced better growth performance and survival than vitamin supplementation alone.

Therefore, dietary vitamin supplementation should be adjusted according to the nutritional requirements of each fish species to achieve optimal aquaculture performance. Appropriate vitamin inclusion not only enhances fish growth and survival but also improves feed efficiency and fish health, ultimately supporting sustainable and economically efficient freshwater aquaculture. Further studies are recommended to determine species-specific vitamin requirements and to investigate the synergistic effects of combined vitamin supplementation under different aquaculture systems.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organization related to the material discussed in the manuscript..

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