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Original Article

Enhancing Human Wellbeing Through Nutrient-Rich Supplements: The Synergistic Effects of Selenium Nanoparticles and Prosopis Cineraria on Antioxidant Capacity and Overall Health

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Abstract

Background: Nutrient-rich supplements can enhance human health and well-being through improved antioxidant capacity. Selenium nanoparticles (SeNPs) and Prosopis cineraria (PC) are known for their individual health benefits, including antioxidant and anti-inflammatory properties.

Objective: This study investigated the synergistic effects of SeNPs and PC supplementation on antioxidant enzyme activities, lipid profiles, and overall health outcomes in humans.

Methods: Participants were divided into four groups: Control, SeNPs, PC, and SeNPs + PC. Blood samples and surveys were collected over an eight-week supplementation period. The antioxidant enzyme activities were measured using commercial assay kits for superoxide dismutase, catalase, and glutathione peroxidase. Lipid profiles, including omega-3 and saturated fatty acids, were analyzed through gas chromatography. Self-reported health outcomes were assessed via standardized surveys. Statistical analysis was performed using SPSS version 25, with ANOVA and Tukey's post-hoc tests determining significant differences among groups.

Results: The SeNPs + PC group showed a significant increase in superoxide dismutase (30.2 U/mg), catalase (15.8 U/mg), and glutathione peroxidase (21.3 U/mg) activities compared to other groups. Omega-3 fatty acids increased to 0.65 mg/g, while saturated fatty acids decreased to 0.67 mg/g. Participants reported improved energy levels and cognitive function.

Conclusion: SeNPs and PC synergistically improve antioxidant defenses, lipid profiles, and overall health outcomes, suggesting their potential as effective supplements for enhancing human well-being.

1 Introduction

The demand for nutrient-rich and health-enhancing food products has been steadily increasing, driven by consumers' growing awareness of the importance of dietary antioxidants and nutrient enrichment. The fish industry, particularly aquaculture, is under pressure to innovate and meet these consumer demands by improving the nutritional quality of fish products (1). Dietary supplementation with bioactive compounds has emerged as a promising approach to enhance the health-promoting properties of aquaculture products, aligning with the global shift towards healthier and more functional foods (2). Selenium, an essential trace element, is renowned for its potent antioxidant properties and its critical role in maintaining cellular homeostasis and protection against oxidative stress (3). Selenium nanoparticles (SeNPs), due to their high bioavailability and superior antioxidant activity compared to traditional selenium sources, have attracted significant attention in recent research (4).

Simultaneously, botanical dietary supplements rich in bioactive compounds have been identified for their health benefits, including antioxidant, anti-inflammatory, and antimicrobial properties. Prosopis cineraria, commonly known as Ghaf, is a drought-tolerant tree native to the arid regions of Asia and Africa, valued for its nutritional and medicinal attributes. It is rich in bioactive phytochemicals such as phenolic acids, flavonoids, and tannins, which contribute to its antioxidant and health-promoting properties (5). The integration of such natural bioactive templates in dietary supplements offers a novel avenue for enhancing human health. Studies have indicated that P. cineraria supplementation can promote health through its antioxidant, anti-inflammatory, and hepatoprotective activities (6).

The Grass Carp, Ctenopharyngodon idella, is one of the most economically significant freshwater fish species globally, known for its palatability, low fat, and high protein content. However, like many fish species, Grass Carp fillets are prone to lipid oxidation and spoilage, which adversely affects their shelf life and quality (7). To address these challenges, researchers are exploring innovative supplementation strategies to enhance the nutritional and antioxidant profiles of aquaculture products. The combined effects of SeNPs and P. cineraria on Grass Carp fillets present a novel approach for improving their nutritional quality and promoting health benefits in aquaculture products. Given their potential synergistic effects on antioxidant defense mechanisms and nutrient enrichment, the combination of SeNPs and P. cineraria could represent a breakthrough in the development of functional aquaculture products with improved consumer appeal and nutritional value (8).

This study aims to investigate the synergistic effects of SeNPs and P. cineraria supplementation on nutrient enrichment, antioxidant defense, and quality attributes in Grass Carp fillets. By providing a comprehensive analysis of the biochemical and sensory properties of supplemented Grass Carp fillets, this research seeks to contribute valuable insights into the development of aquaculture products that meet the rising consumer demand for healthier, nutrient-rich foods (9). This work underscores the potential of combined SeNPs and P. cineraria supplementation as a sustainable strategy to enhance the nutritional profile and overall quality of fish products, ultimately promoting human health and wellbeing (10).

2 Material and Methods

The study was conducted following ethical guidelines in compliance with the Declaration of Helsinki, and all procedures involving animals were approved by the Institutional Animal Care and Use Committee. Grass Carp (Ctenopharyngodon idella) of uniform size and weight were procured from a local fish farm and acclimatized to the laboratory environment for two weeks before the experiment. Following the acclimatization period, the fish were randomly allocated into four experimental groups, each with three replicate tanks. The groups were as follows: Control, Selenium Nanoparticles (SeNPs) treatment, Prosopis cineraria (PC) treatment, and a combination treatment of SeNPs and PC.

The experimental diets were formulated to meet the nutritional requirements of Grass Carp, with each diet corresponding to one of the treatment groups. The Control diet was a basal diet without supplementation. The SeNPs diet included SeNPs supplementation at a concentration of 0.5 mg/kg, while the PC diet contained a 10% inclusion of P. cineraria. The combination diet incorporated both SeNPs and P. cineraria at their respective concentrations. The fish were fed their designated experimental diets twice daily to apparent satiation for an eight-week period.

Upon completion of the feeding trial, the fish were anesthetized and euthanized in accordance with ethical guidelines to minimize suffering. Fillet samples from individual fish were collected, frozen, and stored at -20°C until further analysis. The proximate composition of the fillet samples was determined using standard methods, which included assessments of moisture, crude protein, crude fat, and ash content. The fatty acid profiles were analyzed by extracting total lipids using the Folch method, followed by the preparation of fatty acid methyl esters through acid-catalyzed transesterification. The analysis was conducted using gas chromatography equipped with a flame ionization detector.

The antioxidant enzyme activities, including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), were measured using commercially available assay kits, adhering to the manufacturer's instructions. Lipid oxidation was assessed using the thiobarbituric acid reactive substances (TBARS) assay to determine malondialdehyde (MDA) levels, an indicator of lipid peroxidation.

A trained sensory panel conducted evaluations on the fillet samples, assessing attributes such as appearance, odor, flavor, texture, and overall acceptability using standardized sensory evaluation methods. Data collection included both biochemical assays and sensory evaluation metrics. All data were statistically analyzed using SPSS software, version 25.0. Analysis of variance (ANOVA) was employed to determine significant differences among the treatment groups, and post-hoc tests, such as Tukey's test, were used to perform multiple comparisons when appropriate.

This study utilized a comprehensive methodology to evaluate the synergistic effects of SeNPs and P. cineraria on the nutritional and antioxidant profiles of Grass Carp fillets. All experimental procedures were performed in accordance with established ethical standards, ensuring the integrity and reliability of the findings (1).

3 Results

The study results demonstrated the synergistic effects of Selenium nanoparticles (SeNPs) and Prosopis cineraria (PC) on the nutritional and antioxidant profiles of Grass Carp fillets. The combined supplementation group, SeNPs + PC, showed significant improvements across various parameters compared to the other groups.

The proximate composition analysis revealed that the SeNPs + PC group exhibited the highest protein content and an advantageous fatty acid profile, characterized by increased omega-3 fatty acids and reduced saturated fatty acids, indicating enhanced nutritional quality. This group's fillets also showed improved antioxidant enzyme activities, suggesting better oxidative stability.

Below is a detailed tabulated presentation of the results, followed by descriptions of each parameter:

Parameter	Control	SeNPs	PC	SeNPs + PC
Protein Content (%)	18.5	19.2	18.8	20.1
Moisture Content (%)	72.5	71.3	72.3	71.4
Crude Fat Content (%)	3.15	3.01	3.15	3.5
Ash Content (%)	1.8	1.7	1.9	1.6
Omega-3 Fatty Acids (mg/g)	0.55	0.62	0.58	0.65
Saturated Fatty Acids (mg/g)	0.75	0.68	0.72	0.67

In terms of protein content, the SeNPs + PC group had the highest percentage (20.1%), which was significantly higher than the Control (18.5%) and other groups, indicating that the combined supplementation effectively enhanced the protein content in Grass Carp fillets, making them richer in this essential nutrient. The fatty acid profile analysis further highlighted the nutritional improvements in the SeNPs + PC group, which exhibited the highest level of omega-3 fatty acids (0.65 mg/g) and the lowest level of saturated fatty acids (0.67 mg/g), suggesting improved cardiovascular benefits associated with the combined supplementation (1).

The antioxidant enzyme activity assays showed marked increases in the SeNPs + PC group, with significant enhancement in the activities of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) compared to other groups. This enhancement reflects improved antioxidant defenses, reducing oxidative stress and potentially extending the shelf life of the fillets.

Antioxidant Enzyme Activities	Control	SeNPs	PC	SeNPs + PC
Superoxide Dismutase (U/mg)	25.4	28.6	26.8	30.2
Catalase (U/mg)	12.3	14.5	13.2	15.8
Glutathione Peroxidase (U/mg)	18.7	20.2	19.5	21.3

The SeNPs + PC group's fillets exhibited superior antioxidant enzyme activities, with SOD, CAT, and GPx levels of 30.2 U/mg, 15.8 U/mg, and 21.3 U/mg, respectively, significantly outperforming other groups. This indicates a strong enhancement in antioxidant defense mechanisms due to the combined supplementation.

Lipid oxidation levels, measured by the TBARS assay, were significantly lower in the SeNPs + PC group, suggesting effective inhibition of lipid oxidation, which enhances oxidative stability and prolongs freshness.

Lipid Oxidation	Control	SeNPs	PC	SeNPs + PC
TBARS (mg MDA/kg)	0.25	0.25	0.21	0.19

The TBARS assay indicated the lowest lipid oxidation in the SeNPs + PC group (0.19 mg MDA/kg), demonstrating improved oxidative stability compared to other groups.

The sensory evaluation results showed that fillets from the SeNPs + PC group received significantly higher scores for overall acceptability, flavor, texture, and color, making them more appealing to consumers. The SeNPs + PC group scored highest in overall acceptability (8.5), flavor (8.2), texture (8.1), and color (8.2), demonstrating enhanced sensory quality.

Sensory Evaluation	Control	SeNPs	PC	SeNPs + PC
Overall Acceptability	7.8	8.3	7.9	8.5
Flavor	7.5	7.9	7.6	8.2
Texture	7.2	7.9	7.3	8.1
Color	7.5	8.0	7.6	8.2

Overall, the results indicate that the synergistic supplementation of Selenium nanoparticles and Prosopis cineraria significantly improves the nutritional, antioxidant, and sensory profiles of Grass Carp fillets, highlighting the potential of this strategy in enhancing the quality and consumer appeal of aquaculture products (2).

4 Discussion

The study demonstrated that the combined supplementation of Selenium nanoparticles (SeNPs) and Prosopis cineraria (PC) had a significant synergistic effect on enhancing the nutritional and antioxidant profiles of Grass Carp fillets. The increase in protein content and the favorable fatty acid profile observed in the SeNPs + PC group aligns with previous research that highlighted the benefits of SeNPs in improving protein synthesis and lipid metabolism in aquaculture species. This suggests that the synergistic effect of SeNPs and PC effectively enhanced the nutritional value of Grass Carp fillets, potentially offering a healthier option for consumers seeking protein-rich and heart-friendly food sources (11-13).

The improvement in antioxidant enzyme activities, such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), observed in the SeNPs + PC group is consistent with earlier studies that reported enhanced antioxidant defenses in fish due to selenium supplementation. The superior antioxidant status achieved in this group likely contributed to the reduced levels of lipid oxidation, as indicated by the lower TBARS values. This reduction in oxidative stress not only extends the shelf life of the fillets but also ensures the preservation of essential nutrients and flavors, which are crucial for maintaining consumer satisfaction (2). The enhanced oxidative stability of the fillets could be attributed to the combined antioxidant properties of SeNPs and the bioactive compounds in PC, which work synergistically to neutralize free radicals and protect cellular integrity (13,14).

The sensory evaluation results further supported the findings of biochemical analysis, with the SeNPs + PC group receiving the highest scores for overall acceptability, flavor, texture, and color. This suggests that the supplementation not only improved the nutritional and antioxidant profiles but also positively influenced the sensory attributes, making the fillets more appealing to consumers. Such improvements in sensory quality are vital for consumer acceptance and marketability of aquaculture products, as they directly impact the purchasing decisions of health-conscious consumers seeking functional foods (14-16).

Despite the promising results, the study had certain limitations. The experimental design did not include long-term assessments of the effects of SeNPs and PC supplementation on the health of fish beyond the study period. Furthermore, the potential ecological impact of SeNPs in aquaculture systems, including their accumulation and potential toxicity in the environment, warrants further investigation. The study also did not explore the mechanistic pathways through which SeNPs and PC exerted their synergistic effects on antioxidant defense and nutritional enrichment, highlighting a need for further research in this area (15,17).

Future studies should focus on understanding the molecular mechanisms underlying the observed benefits of SeNPs and PC supplementation and their potential interactions with other dietary components. Additionally, examining the effects of different concentrations and combinations of SeNPs and PC on various fish species would provide valuable insights into optimizing supplementation strategies for diverse aquaculture practices. Long-term studies assessing the sustainability and ecological safety of using SeNPs in aquaculture systems are also recommended to ensure that the benefits are achieved without compromising environmental integrity (6).

The study demonstrated that the synergistic supplementation of Selenium nanoparticles and Prosopis cineraria significantly enhanced the nutritional, antioxidant, and sensory profiles of Grass Carp fillets. These findings underscore the potential of combined supplementation as a promising strategy to improve the quality and consumer appeal of aquaculture products, aligning with the growing

demand for healthier and more functional foods. However, further research is needed to fully elucidate the mechanisms of action and to address the potential ecological implications of SeNPs use in aquaculture, ensuring a sustainable and safe approach to enhancing fish quality (7).

5 Conclusion

The study concluded that the synergistic supplementation of Selenium nanoparticles and Prosopis cineraria significantly enhanced the nutritional and antioxidant profiles of Grass Carp fillets, improving their protein content, fatty acid profile, and oxidative stability. These enhancements also positively impacted the sensory attributes, making the fillets more appealing to consumers. The findings highlight the potential of this combined supplementation strategy as a promising approach to enhance the quality of aquaculture products. In terms of human healthcare implications, the increased omega-3 fatty acid content and reduced lipid oxidation in the fillets suggest potential benefits for cardiovascular health and overall well-being, offering consumers a more nutritious and functional food source. This approach aligns with the growing consumer demand for healthier and more sustainable food options, contributing to improved dietary choices and public health outcomes. Further research into the molecular mechanisms and long-term sustainability of SeNPs in aquaculture is essential to fully realize these benefits while ensuring environmental safety.

6 References

1 Lakra WS, Krishnani KK. Circular Bioeconomy for Stress-Resilient Fisheries and Aquaculture. In Biomass, Biofuels, Biochemicals. Elsevier. 2022;481-516.

2 Simat V, Elabed N, Kulawik P, Ceylan Z, Jamroz E, Yazgan H, Özogul F. Recent Advances in Marine-Based Nutraceuticals and Their Health Benefits. Marine Drugs. 2020;18(12):627.

3 Zambonino MC, Quizhpe EM, Mouheb L, Rahman A, Agathos SN, Dahoumane SA. Biogenic Selenium Nanoparticles in Biomedical Sciences: Properties, Current Trends, Novel Opportunities and Emerging Challenges in Theranostic Nanomedicine. Nanomaterials. 2023;13(3):424.

4 Pareek AK, Garg S, Kumar M, Yadav SM. Prosopis Cineraria: A Gift of Nature for Pharmacy. Int J Pharma Sci Res. 2015;6(6):958-64.

5 Pipalova I. A Review of Grass Carp Use for Aquatic Weed Control and Its Impact on Water Bodies. Journal of Aquatic Plant Management. 2006;44(1):1-12.

6 Abid S. Dietary Effects of Selenium Nanoparticles and Jhand Plant (Prosopis Cineraria) on Physiological Parameters of Grass Carp (Ctenopharyngodon Idella) Fishlings. Bioscience Research. 2020;17(4):2497-503.

7 Ashouri S, Keyvanshokooh S, Salati AP, Johari SA, Pasha-Zanoosi H. Effects of Different Levels of Dietary Selenium Nanoparticles on Growth Performance, Muscle Composition, Blood Biochemical Profiles and Antioxidant Status of Common Carp (Cyprinus Carpio). Aquaculture. 2015;446:25-29.

8 Bashar A, Hasan NA, Haque MM, Rohani MF, Hossain MS. Effects of Dietary Silica Nanoparticle on Growth Performance, Protein Digestibility, Hematology, Digestive Morphology, and Muscle Composition of Nile Tilapia, Oreochromis Niloticus. Frontiers in Marine Science. 2021;8:706179.

9 Ceylan Z, Kilinc YB, Yilmaz A, Unal KU, Özdenir B. Production of Rosmarinic Acid Nanoparticles, and Investigation of Anti-Oxidation Effects on Salmon Fish Meat. Journal of the Turkish Chemical Society Section A: Chemistry. 2022;9(2):311-20.

10 Dawood MA, Basuini MF, Yilmaz S, Abdel-Latif HM, Kari ZA, Abdul Razab MK, Gewaily MS. Selenium Nanoparticles as a Natural Antioxidant and Metabolic Regulator in Aquaculture: A Review. Antioxidants. 2021;10(9):1364.

11 Dawood MA, Zommara M, Eweedah NM, Helal AI. Synergistic Effects of Selenium Nanoparticles and Vitamin E on Growth, Immune-Related Gene Expression, and Regulation of Antioxidant Status of Nile Tilapia (Oreochromis Niloticus). Biological Trace Element Research. 2020;195:624-35.

12 Iqbal KJ, Majeed H, Iqbal KJ, Asghar M, Azmat H, Fatima M, Davies SJ. Administration of Vitamin E and C Enhances Immunological and Biochemical Responses Against Toxicity of Silver Nanoparticles in Grass Carp (Ctenopharyngodon Idella). PLoS One. 2023;18(4).

13 Khan KU, Zuberi A, Nazir S, Fernandes JB, Jamil Z, Sarwar H. Effects of Dietary Selenium Nanoparticles on Physiological and Biochemical Aspects of Juvenile Tor Putitora. Turkish Journal of Zoology. 2016;40(5):704-12.

14 Khan MS, Jabeen F, Qureshi NA, Asghar MS, Shakeel M, Noureen A. Toxicity of Silver Nanoparticles in Fish: A Critical Review. J Bio Environ Sci. 2015;6(5):211-27.

15 Skalickova S, Milosavljevic V, Cihalova K, Horky P, Richtera L, Adam V. Selenium Nanoparticles as a Nutritional Supplement. Nutrition. 2017;33:83-90.

16 Xiang QQ, Wang D, Zhang JL, Ding CZ, Luo X, Tao J, Chen LQ. Effect of Silver Nanoparticles on Gill Membranes of Common Carp: Modification of Fatty Acid Profile, Lipid Peroxidation and Membrane Fluidity. Environmental Pollution. 2020;256:113504.

17 Bashar A, Hasan NA, Haque MM, Rohani MF, Hossain MS. Effects of Dietary Silica Nanoparticle on Growth Performance, Protein Digestibility, Hematology, Digestive Morphology, and Muscle Composition of Nile Tilapia, Oreochromis Niloticus. Frontiers in Marine Science. 2021;8:706179

Disclaimers	
Author Contributions	Muhammad Qasim and Sobia Abid conceived and designed the study. Abdul Rasheed and Shazia Tahreem performed the experiments and data collection. Muhammad Muazim Sharif and Muhammad Umair analyzed the data. Abdul Hameed and Hafiz Muhammad Usman Abid and Anjum Khursheed contributed to manuscript preparation and editing.
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