

Exploring the Changes in Indicators of Non-indigenous Pearl Oyster *Pinctada imbricata radiata* (Leach, 1814) from the West of the Aegean Sea, Greece during Different Seasons

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Abstract This review mainly focuses on the recently published research titled “ Seasonal Variation in the Biochemical Composition, Condition Index, and Meat Yield of the Non-indigenous Pearl Oyster *Pinctada imbricata radiata* (Leach, 1814) from the West of the Aegean Sea, Greece”. The research compared the biochemical composition, condition indicators, and meat yield of the non native pearl oyster (*Pinctada imbricata radiata*) in the western Aegean Sea during seasonal changes through a large amount of sample data. This review provides important reference and theoretical basis for further exploring the potential of pearl oysters in aquaculture and fishery development by interpreting research data and results. In addition, this review also emphasizes the health benefits of shellfish foods and the potential for promoting pearl oysters as edible bivalves. These findings are of great significance for marine resource management and sustainable development, providing new perspectives and opportunities for the development of pearl oyster farming and shellfish food industry.

Keywords Pearl oyster; Biochemical composition; Condition index; Meat yield; Seasonal variation

As the global population continues to grow, and the demand for marine resources steadily increases, the quest for new sources of marine food becomes particularly significant. The bivalves in the ocean, such as shellfish, have garnered attention due to their rich nutritional content and sustainable farming potential. Pearl oysters, besides producing exquisite pearls, also offer their flesh for human consumption. However, research on the seasonal variations and nutritional value of pearl oysters remains relatively limited (Yassien et al., 2000; Tlig-Zouari et al., 2009; 2010; Yigitkurt, 2021).

This review primarily elucidates the seasonal variations in the biochemical composition, condition indicators, and meat yield of non-native pearl oysters (*Pinctada imbricata radiata*) in the Western Aegean Sea. By collecting and analyzing samples of these pearl oysters across different seasons, researchers explore the trends in their biochemical composition and nutritional value. In addition, they also studied the seasonal changes in condition indicators and meat yield to understand the physiological status and quality characteristics of pearl oysters in different seasons.

Through this review, we aim to provide a reference and theoretical basis for further exploration of the potential of non-native pearl oysters (*Pinctada imbricata radiata*) in aquaculture and fisheries development. Additionally, this review emphasizes the health benefits of consuming bivalve shellfish and underscores the promotional potential of pearl oysters as edible bivalve mollusks. These findings offer valuable insights for marine resource management and sustainable development, opening new opportunities and directions for the pearl oyster farming and shellfish food industry. Nevertheless, researchers still need to conduct further studies to gain in-depth insights into the biological characteristics and aquaculture potential of pearl oysters under various environmental conditions to ensure their sustainable utilization and preservation.

1 Research Overview

This study primarily focuses on the seasonal variations in the biochemical composition, condition indicators, and meat yield of non-native pearl oysters (*Pinctada imbricata radiata*) in the Western Aegean Sea. Researchers collected pearl oyster samples from different seasons in Sarónikos Bay and Evoikos Gulf (Figure 1) and conducted biochemical analyses and physical condition assessments. The objective was to comprehend the changes in the nutritional components and quality characteristics of pearl oysters under varying seasonal conditions (Biandolino et al., 2020).



Figure 1 Pearl oyster sampling positions in the gulfs of Saronikos (37° 59' 113" / 23° 26' 059") and Evoikos (38° 30' 783" / 23° 32' 254"), W. Aegean Sea, Greece (Theodorou et al., 2023)

The biochemical composition of pearl oysters is a crucial indicator for assessing their nutritional value. Researchers measured the protein, fat, sediment, carbohydrate, and water content in pearl oyster samples, comparing differences between samples from different seasons (Figure 2). The results revealed that pearl oysters are rich in protein, with relatively low fat content and moderate carbohydrate levels. These variations in nutritional components may be associated with the pearl oysters' growth cycles and food supply. For instance, during the summer, pearl oysters exhibited higher protein content, possibly due to the warmer water temperatures and abundant food supply, which favor their growth and metabolic activities. In contrast, during the winter, lower water temperatures and reduced food supply led to relatively lower protein content in pearl oysters. Additionally, there were variations in the biochemical composition of pearl oysters in different regions of the Mediterranean. These data provide essential information about variations in nutritional components in pearl oysters, contributing to an understanding of their nutritional value across different seasons.

In addition to the biochemical composition, researchers also assessed the condition indices and flesh yield of pearl oysters (Figure 3). Condition indicators are indicators used to evaluate the health and physiological status of pearl oysters, based on observations of their external morphology and internal structural changes. Meat yield is an important parameter for assessing the quality and quantity of the edible portion of pearl oysters. Through observations and measurements of samples from different seasons, researchers discovered significant variations in the condition indicators and meat yield of pearl oysters between different seasons. During the summer, when water temperatures are favorable and food is abundant, pearl oysters exhibited higher condition indicators and relatively higher meat yield. In contrast, during the winter, due to lower water temperatures and reduced food supply, both the condition indicators and meat yield of pearl oysters were relatively lower. These findings suggest that pearl oysters are more suitable as a food source during the summer, offering higher quality and yield.

By reviewing the seasonal changes in pearl oysters, this review aims to provide an in-depth understanding of the biochemical composition, condition indicators, and meat yield of non-native pearl oysters (*Pinctada imbricata radiata*) in the Western Aegean Sea. These data will contribute to the assessment of the potential of pearl oysters as a food source and offer guidance and reference for the development of pearl oyster aquaculture and the

shellfish food industry. By comprehending the growth and metabolic patterns of pearl oysters in different seasons, aquaculturists can optimize their farming environments and feeding management, ultimately enhancing the quality and yield of pearl oysters. This not only aids in providing a greater food resource but also stimulates local economic development. Furthermore, these research findings hold significant importance for marine resource management and sustainability. By understanding the biological and quality characteristics of pearl oysters in different seasons, people can better manage and protect their population resources to achieve sustainable development and protect marine ecosystems.

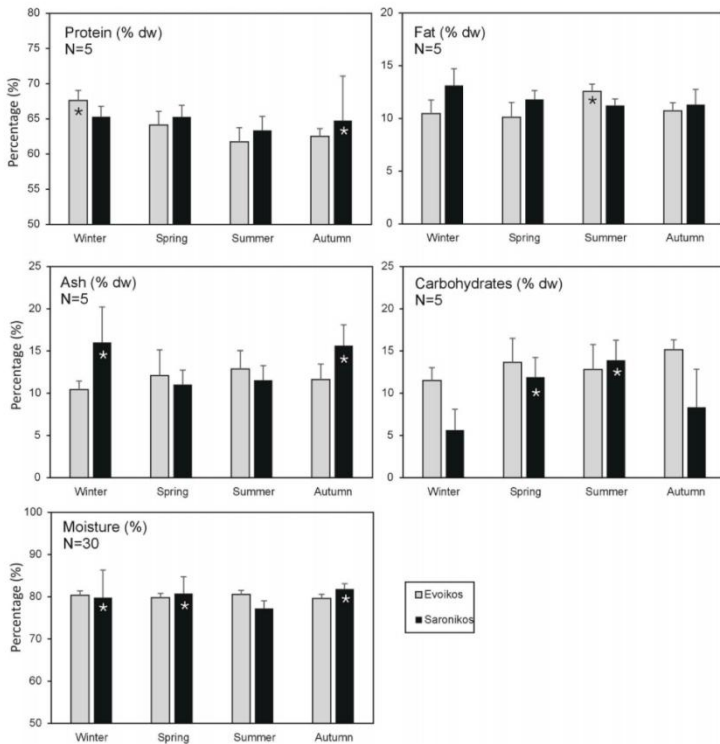


Figure 2 Seasonal variation of pearl oyster biochemical composition for the gulfs of Evoikos and Saronikos in W. Aegean Sea (mean values and SD) (Theodorou et al., 2023)

Note: Asterisks denote statistically higher values among seasons in each region (Kruskal-Wallis, $P < 0.05$)

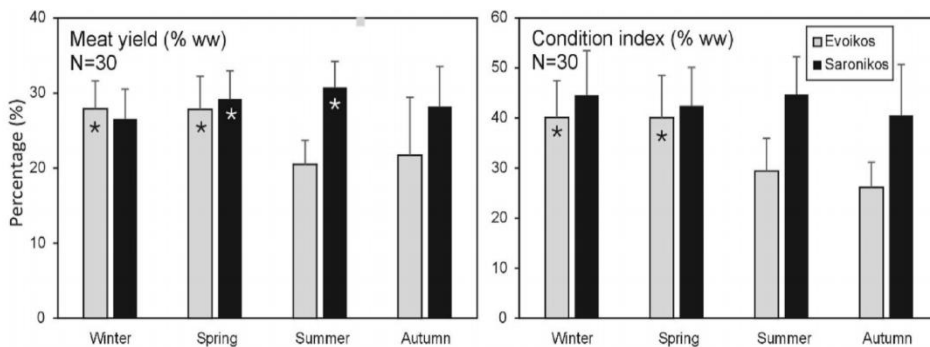


Figure 3 Seasonal variation of condition index (CI) and meat yield (MY) of pearl oyster in Evoikos and Saronikos gulfs (mean values and SD) (Theodorou et al., 2023)

Note: Asterisks denote statistically higher values among seasons in each region (Kruskal-Wallis, $P < 0.05$)

2 Innovations and Contributions

2.1 Innovative aspects of the study

This study offers a novel perspective by measuring the protein, fat, and carbohydrate content in pearl oyster samples, providing detailed data on their biological and quality characteristics, and revealing intricate information about the seasonal variations in nutritional components of pearl oysters. Such research findings have been

relatively scarce in the past, offering a fresh angle to understand the nutritional value of pearl oysters. Moreover, this study fills gaps in knowledge regarding the biological and quality characteristics of pearl oysters. It lays the foundation for future research and delving deeper into the ecological and physiological aspects of pearl oysters. By assessing the condition indicators and meat yield of pearl oysters, researchers highlight the health status and quality characteristics of the edible portions of pearl oysters during different seasons. This is of paramount importance for the management of pearl oyster aquaculture and the shellfish food industry. Additionally, this study unveils the impact of environmental factors on the growth and quality of pearl oysters through an investigation of their biological and quality characteristics in various seasons. This information aids in formulating more effective marine resource management measures, preserving pearl oyster population resources, and ensuring their sustainable utilization.

2.2 Contributions of the study

Through an in-depth exploration of the biological and quality characteristics of pearl oysters, this study provides essential references and guidance for marine resource management and sustainable development. For instance, optimizing aquaculture environments and feeding management to enhance the quality and yield of pearl oysters, thus fostering local economic development. Additionally, an understanding of the biological and quality characteristics of pearl oysters across different seasons enables the formulation of more scientifically grounded aquaculture management strategies to improve the efficiency and quality of pearl oyster farming. This holds significant importance for the development of the shellfish food industry, enabling a more sustainable supply of shellfish products. This study fills the knowledge gap regarding the biological and quality characteristics of pearl oysters. This provides a foundation for future research and lays the foundation for deeper exploration of the ecological and physiological characteristics of pearl oysters.

3 Future Research Directions

This study primarily relied on sample data from two experimental sites to conduct data analysis and discussions, elucidating the biochemical composition, condition indicators, and meat yield of the non-native pearl oyster (*Pinctada imbricata radiata*) in the Western Aegean Sea during seasonal changes. However, relying solely on experimental samples for analysis has certain limitations, and additional verification from multiple sources is needed to enhance the accuracy of inferences. Moreover, the research content can be more comprehensive and diverse to further improve the understanding of pearl oysters, providing a more scientific basis for their protection, cultivation, and utilization.

A more in-depth exploration of the ecological aspects of pearl oysters is necessary, which will aid in better comprehending their roles and functions within marine ecosystems. Aquaculture experts can investigate the ecological behaviors of pearl oysters, such as their life history, feeding habits, and reproductive behaviors. By understanding the impact of pearl oysters on substrate and water quality, as well as their interactions with other organisms, their significance in marine ecosystems can be unveiled. This will help better protect and manage pearl oyster populations, while also contributing to the health and stability of marine ecosystems.

Further research into the genetics of pearl oysters will provide essential foundations for the protection and management of pearl oyster populations. By analyzing the genetic diversity and structure of pearl oysters, people can understand the genetic variation of pearl oyster populations and the genetic connections between populations. This will assist in determining population boundaries, genetic flow, and the overall health of pearl oyster populations. Based on this information, people can develop scientific conservation and management strategies to ensure the long-term survival of pearl oyster populations and the maintenance of genetic diversity. Additionally, genetic research can guide pearl oyster aquaculture, aiding in the selection of superior genetic strains to enhance pearl oyster production and quality.

A more in-depth exploration of pearl oyster aquaculture techniques will bring forth additional opportunities for the marine industry. Pearl oyster farming is a significant economic activity, and improvements and innovations in aquaculture techniques will enhance efficiency, reduce resource consumption, and minimize environmental

impacts. Through the adoption of advanced aquaculture technologies, such as recirculating aquaculture systems and genetic modifications, aquaculturists can accelerate pearl oyster growth, bolster disease resistance, and enhance pearl quality. This will lead to increased availability of pearl oyster products to meet market demands while reducing dependence on wild pearl oyster resources.

A comprehensive investigation into the nutritional quality of pearl oysters holds significant importance. Pearl oysters are rich in nutrients such as proteins, minerals, and vitamins, making them highly nutritious. Analyzing the nutritional composition and functional components of pearl oysters can provide further insights into their potential health benefits for human consumption. This will provide people with a healthier and more nutritious choice of shellfish food, promoting a healthy lifestyle.

Continued research into the ecology, genetics, aquaculture techniques, nutritional quality, and environmental adaptability of pearl oysters can furnish additional scientific foundations and innovative approaches for their conservation, cultivation, and utilization. Such endeavors will contribute to advancing marine science, fostering the sustainable development of the pearl oyster industry, and offering consumers higher-quality shellfish products and pearl items. In future studies, researchers may also explore the adaptability of pearl oysters concerning environmental changes. Given the substantial alterations occurring in marine environments due to climate change and human activities, understanding how pearl oysters respond to these changes and their adaptive mechanisms can aid in anticipating and addressing future environmental transformations. Investigating their resilience, adaptability, and genetic adaptability can provide more scientific insights into the adaptation and protection of marine ecosystems.

4 Conclusion

The future directions of pearl oyster research are brimming with opportunities and challenges. By delving deeper into the ecology, genetics, aquaculture techniques, nutritional quality, and environmental adaptability of pearl oysters, researchers can provide a stronger scientific foundation and innovative methods for their conservation, cultivation, and utilization. Moreover, these research avenues will also drive the advancement of marine science, promote sustainable growth within the pearl oyster industry, and offer people a wider array of high-quality shellfish foods and pearl products.

However, within these research directions, individuals are confronted with several challenges and difficulties. Pearl oyster research demands substantial time, funding, and concerted effort. From ecological surveys of pearl oysters to genetic analyses and aquaculture experiments, sustained dedication and patience are prerequisites. Simultaneously, it is essential to maintain focus on the sustainable use and protection of pearl oysters and their habitats. Factors such as overfishing, habitat degradation, and pollution pose threats to the survival of pearl oyster populations and the well-being of ecosystems. Therefore, researchers must collaborate closely with governments, academia, industry, and society to develop and implement effective conservation and management strategies.

Pearl oyster research is not limited to the scientific field, but also carries cultural and economic significance. Pearls are revered as precious symbols in many cultures and are considered vital materials for jewelry and adornments. Through investigations into the ecology, genetics, and aquaculture techniques of pearl oysters, people can better conserve and utilize this valuable resource while also fostering the preservation of cultural heritage and economic development, allowing pearl oysters to be studied and applied more comprehensively.

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