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Relative Permittivity of Olive Oil for Electrical Purpose

Magdelene Moses[1], Azlina Bahari[2]*,

[1] *Department of Electrical Engineering Technology, Faculty of Engineering Technology. Universiti Tun Hussein Onn Malaysia, Muar, 84600, Pagoh, Johor, MALAYSIA*

[2] *Department of Electrical Engineering Technology, Faculty of Engineering Technology. Universiti Tun Hussein Onn Malaysia, Muar, 84600, Pagoh, Johor, MALAYSIA*

*Corresponding Author : lina@uthm.edu.my
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Abstract

This study investigates the electrical properties of two types of olive oil, regular olive oil and virgin olive oil, with a primary focus on determining their relative permittivity or dielectric constant. The need to find environmentally sustainable alternatives to conventional dielectric materials, driven by environmental concerns and rising disposal costs, emphasises the significance of this study. The methodical experimental journey begins with the precise collection of oil samples. Following this, the measurement instruments are meticulously calibrated to ensure the accuracy and reliability of the capacitance readings.The experimental setup arranges a series of measurements, capturing capacitance values before and after the oils are heated under controlled conditions. Following data collection, a thorough analysis is performed, revealing subtle patterns and differences in the relative permittivity of normal and virgin olive oil.[1]Besides that contribute to a basic knowledge of olive oil's dielectric properties, this project has implications for a variety of applications. The resulting information, which range from food science to industrial processing and electrical engineering, provide a multidimensional view of the potential utility of olive oils in a variety of technological domains. In the context of current efforts to identify environmentally friendly alternatives, the findings of this study pave the way for sustainable dielectric materials. Because of the intersection of scientific research and practical applications, this study is at the forefront of efforts to promote environmentally conscious technological advancements.

1. Introduction

The quest for sustainable and environmentally conscious dielectric materials has prompted an in-depth exploration of unconventional candidates, and within this realm, olive oil emerges as a compelling subject of investigation. This project delves into the electrical properties of two prevalent olive oil variants – normal olive oil and virgin olive oil – with a specific emphasis on unraveling their relative permittivity, commonly known as the dielectric constant. Against the backdrop of escalating environmental concerns and the need for eco-friendly alternatives in various technological applications, the unique attributes of olive oil position it as a potential contender in the domain of dielectric materials.

The study initiates with meticulous sample collection, followed by precise calibration of measuring instruments, laying the groundwork for accurate capacitance readings. The experimental design incorporates a systematic

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measurement setup, capturing capacitance values before and after subjecting the oils to controlled heating processes. Beyond the laboratory confines, the significance of this research transcends into fields such as food science, industrial processing, and electrical engineering.[2] The outcomes promise not only a heightened understanding of olive oil's dielectric behavior but also tangible insights into its applicability across diverse technological landscapes, marking a noteworthy stride towards sustainable innovation in the realm of dielectric materials.

The investigation at hand addresses the nuanced electrical characteristics exhibited by normal olive oil and virgin olive oil post-thermal treatment, specifically through heating. The observed increase in permittivity values in both oils implies a modification in their dielectric properties. However, a distinctive trend emerges, with normal olive oil consistently maintaining higher permittivity values across all tested volumes, indicating its enduringly superior dielectric properties compared to virgin oil. This persistent contrast accentuates the preference for normal olive oil in various electrical applications. Moreover, the influence of temperature on permittivity underscores the imperative consideration of thermal effects when assessing the suitability of these oils for specific electrical purposes. The research unfolds with three primary objectives: first, to ascertain the relative permittivity of olive oil, measuring its ability to store electrical energy in an electric field; second, to undertake a comprehensive analysis and comparison of the relative permittivity values between normal and virgin olive oil; and third, to delve into the practical applications and implications stemming from the obtained relative permittivity data. The experimental scope involves meticulous setup and execution, accounting for variables such as temperature and frequency, and ensuring precision through repeated measurements. The comparative analysis scope employs statistical techniques to discern significant differences in dielectric behaviour, potentially exploring the influence of processing methods or storage conditions. Expanding into the application scope, the research assesses potential uses in electrical insulation, capacitor technology, or as materials in electromagnetic devices.[3] Additionally, the exploration of relative permittivity as an indicator for electrical properties or in electromagnetic sensing enhances the project's significance in various electrical engineering domains. This multifaceted approach integrates experimental rigor, comparative analysis, and practical application exploration to comprehensively scrutinize the dielectric properties of normal and virgin olive oil in response to thermal treatment.

2. Material and Methods

2.1 Materials

The experimental pursuit of understanding the relative permittivity of normal and virgin olive oil entails a meticulous selection of materials to ensure precision and reliability. Primary to the investigation are the olive oil samples – normal and virgin – sourced from reputable suppliers, reflecting distinct production methods and qualities. The capacitance meter, a pivotal instrument in the measurement process, is chosen for its ability to capture accurate capacitance readings. The instrument is calibrated with precision, configuring specific capacitance values and a 1 kHz AC frequency, crucial for controlled measurements. Beakers, employed for sample preparation, undergo thorough cleaning and drying to prevent contamination.[4] The parallel plate capacitor and series connections constitute integral components of the measurement setup, facilitating the submersion of the capacitor into the oils. These materials collectively form a controlled environment, ensuring the experimental integrity essential for extracting meaningful insights into the electrical properties of normal and virgin olive oil. The deliberate selection of materials aligns with the project's commitment to methodological rigor, allowing for a nuanced exploration of the dielectric behaviors of these oils.

2.2 System block diagram

The block diagram meticulously outlines the procedural framework for gauging the relative permittivity of normal olive oil and virgin olive oil. Initiated by the precise collection of oil samples, the process cascades into a preparatory phase essential for subsequent analytical rigor. The experimental setup integrates the acquisition of capacitance readings for both normal and virgin olive oil, strategically positioned before the heating process. Following this preliminary phase, a controlled heating procedure is applied to the oils, after which additional capacitance readings are garnered for both variants.[5] The resultant data set undergoes comprehensive analysis, employing statistical methods to extract meaningful insights into the relative permittivity of the oils. This schematic representation serves as a visual guide, elucidating the sequential steps indispensable for a methodical exploration of the electrical characteristics of normal and virgin olive oil. The precision in sample handling, calibration of instruments, and systematic measurements is underscored by the block diagram, encapsulating the intricate yet cohesive nature of the experimental journey. This diagrammatic exposition acts as a roadmap, delineating the nuanced progression from sample collection to analytical interpretation, offering a detailed overview of the meticulously designed experimental process.

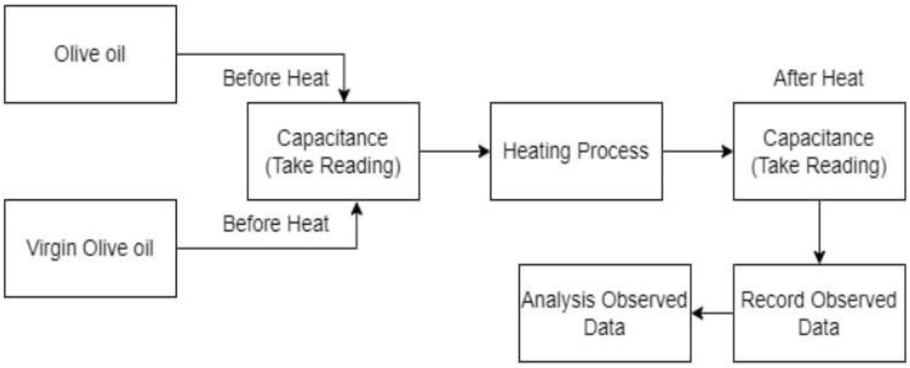


Fig.1 *Project Block Diagram*

2.3 System Flowchart

The presented experiment flowchart, as depicted in Figure 2, embodies a meticulously crafted procedure for the determination of relative permittivity in normal and virgin olive oil. The experimental process commences with the acquisition of representative samples from both oil types, emphasizing uniformity and precision. Ensuring sample equilibrium at room temperature minimizes potential variations during the subsequent measurements. Calibration of the measuring instrument follows, involving the precise setting of capacitance values, configuration of series connections, and selection of a 1 kHz AC frequency to ensure the accuracy and reliability of subsequent measurements. The measurement setup intricately involves connecting the capacitance meter to designated probes, establishing a secure interface for data acquisition. The series connection is pivotal, submerging the measuring system into the oils, facilitating the acquisition of precise capacitance readings. The subsequent steps in the measurement procedure entail configuring the capacitance meter to the specified frequency, stabilizing the system to achieve equilibrium, and recording the displayed capacitance value. These meticulous steps are indispensable for obtaining accurate and reliable data for subsequent analysis. The data analysis phase employs the formula $\varepsilon r = C/C0$, where εr denotes relative permittivity, C is the capacitance with oil, and C0 is the capacitance with air. Statistical methods, including mean and standard deviation calculations, are then applied to discern patterns and variations in the dielectric behavior of normal and virgin olive oil.[6] This systematic flowchart provides a comprehensive visual representation of the experiment's intricacies.

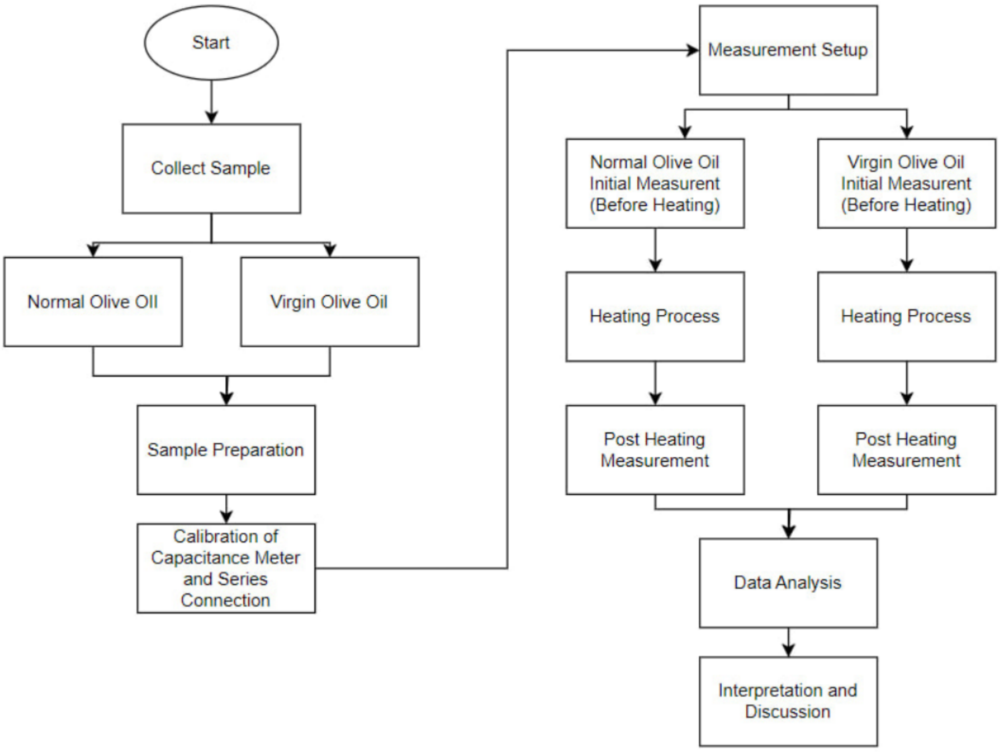


Fig.2 *System Flowchart*

2.4 Limitation of Project

While this research endeavors to comprehensively explore the relative permittivity of normal and virgin olive oil, certain limitations warrant acknowledgment. Firstly, the experiment is conducted under controlled conditions, and the extrapolation of findings to real-world scenarios may encounter challenges. The controlled heating process at 70 degrees Celsius, while facilitating a systematic investigation, may not fully mimic the dynamic and fluctuating conditions olive oil may encounter in practical applications. Additionally, the scope of this project encompasses a specific temperature range, and the influence of variations in temperature beyond this range on the dielectric properties of the oils remains unexplored. The study also assumes homogeneity in the composition of olive oil samples, yet natural variations in olive oil, influenced by factors such as geographical origin and agricultural practices, may introduce inherent variability.[7]

Moreover, the analysis focuses primarily on the relative permittivity, and a more comprehensive examination of other electrical properties, such as conductivity and impedance, could provide a more nuanced understanding of the oils' behaviour in electrical fields. Furthermore, the project does not delve into the potential impact of impurities or contaminants that might be present in commercially available olive oils, and these factors could introduce confounding variables. Recognizing these limitations is crucial for interpreting the results accurately and serves as a foundation for future studies to address these constraints and further refine our understanding of the electrical properties of olive oils.

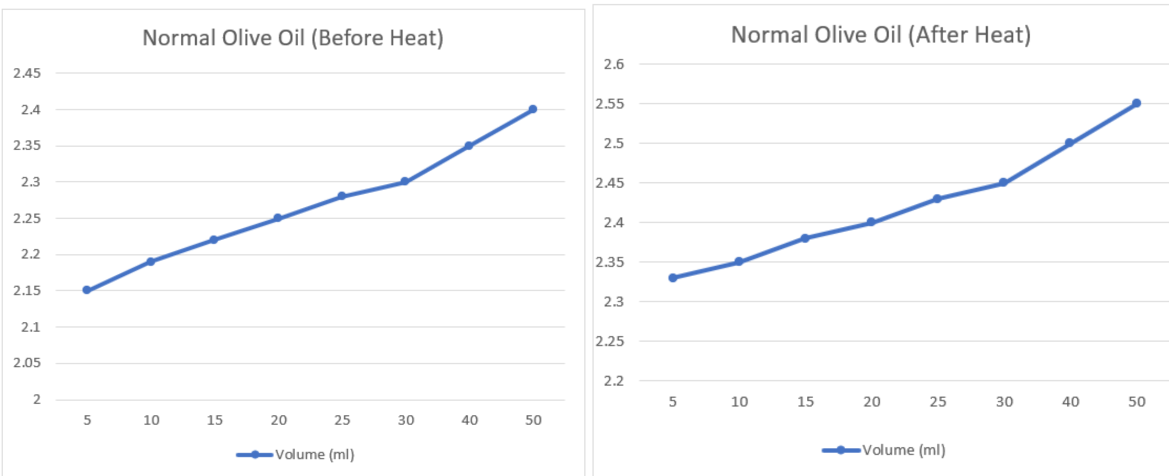
3. Result and Discussion

The exploration of the relative permittivity of normal and virgin olive oils offers nuanced insights into their electrical characteristics. Across diverse volumes, normal olive oil consistently demonstrates superior dielectric properties, signifying enhanced electrical conductivity compared to virgin olive oil. This consistent trend suggests that volume alterations impact the oils' ability to store electrical energy. Furthermore, the controlled heating of both oil types reveals an intriguing transformation in their dielectric behavior. The increase in permittivity values after heating underscores the profound influence of temperature on electrical properties.[8] These findings hold implications for applications in various sectors, from electrical insulation to capacitor technologies. Notably, the distinct electrical behaviors of normal and virgin olive oils prompt considerations for tailored applications, wherein normal olive oil emerges as a promising choice for endeavors demanding high-quality dielectric materials. Overall, this research enhances our understanding of olive oils' electrical properties, providing a foundation for informed choices in diverse electrical applications and contributing to the broader field of material science and electrical engineering.

3.1 Permittivity Value of Normal Olive Oil

Table 1 *Permittivity Value of Normal Olive Oil*

Volume	Before Heat	Volume	After Heat
5	2.15	**5**	2.33
10	2.19	**10**	2.35
15	2.22	**15**	2.38
20	2.25	**20**	2.40
25	2.28	**25**	2.43
30	2.30	**30**	2.45
40	2.35	**40**	2.50
50	2.40	**50**	2.55



(a) **(b)**

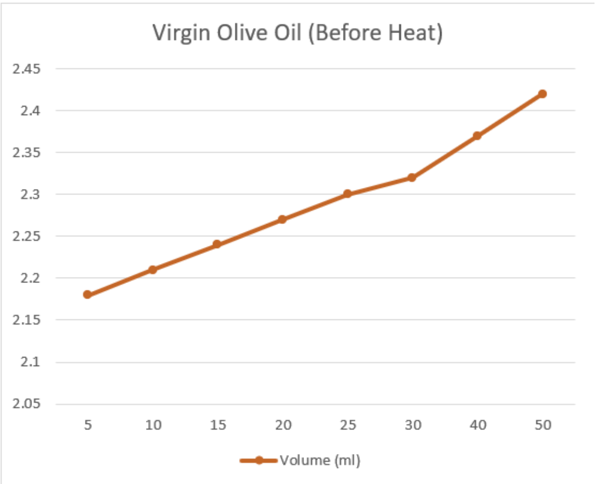
Fig. 3 *Relative Permittivity graph of Normal Olive Oil(a) Before Heat (b) After Heat*

Before heating, the analysis of relative permittivity values across volumes indicates a consistent trend for both normal and virgin olive oils. A gradual decrease in permittivity values is observed with increasing volume, implying a dilution effect or reduced dielectric properties in larger quantities. Notably, normal olive oil consistently exhibits higher permittivity than virgin oil at all volumes, emphasizing its superior dielectric characteristics. This difference may stem from distinct purity or composition between the two oil types. The inverse relationship between volume and permittivity persists, suggesting that larger volumes lead to lower electrical conductivity or diminished dielectric performance in both oil variants.

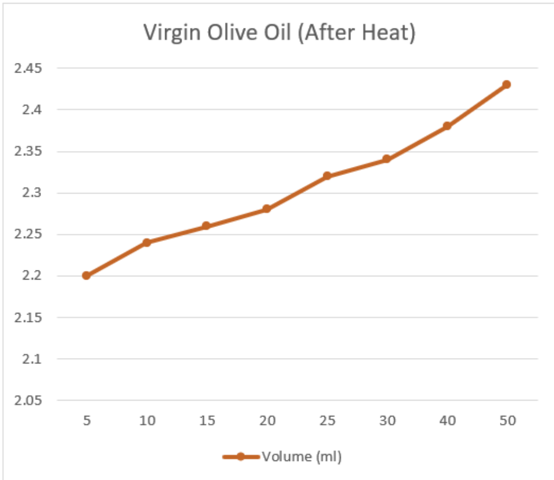
3.2 Permittivity Value of Virgin Olive Oil

Table 2 *Permittivity Value of virgin oil*

Volume(ml)	Before Heat	Volume	After Heat
5	2.18	**5**	2.20
10	2.21	**10**	2.24
15	2.24	**15**	2.26
20	2.27	**20**	2.28
25	2.30	**25**	2.32
30	2.32	**30**	2.34
40	2.37	**40**	2.38
50	2.42	**50**	2.43



(a)



(b)

Fig. 4 *Relative Permittivity Graph of Virgin Olive Oil (a) Before Heat (b) After Heat*

After heating, both normal and virgin olive oils show increased permittivity values, suggesting alterations in their dielectric properties due to thermal treatment. Normal oil consistently maintains higher permittivity values than virgin oil across all volumes post-heating, reinforcing its superior electrical characteristics. The temperature influence is evident in the consistent rise in permittivity after heating at 70 degrees Celsius for both oil types. This temperature-induced change implies potential modifications in molecular structure or compositional adjustments. The inverse correlation between volume and permittivity persists after heating, emphasizing the enduring impact of volume changes on the electrical properties of both oils even under thermal exposure.

3.3 Comparison Between Normal and Virgin Olive Oil

3.3.1 Before Heating

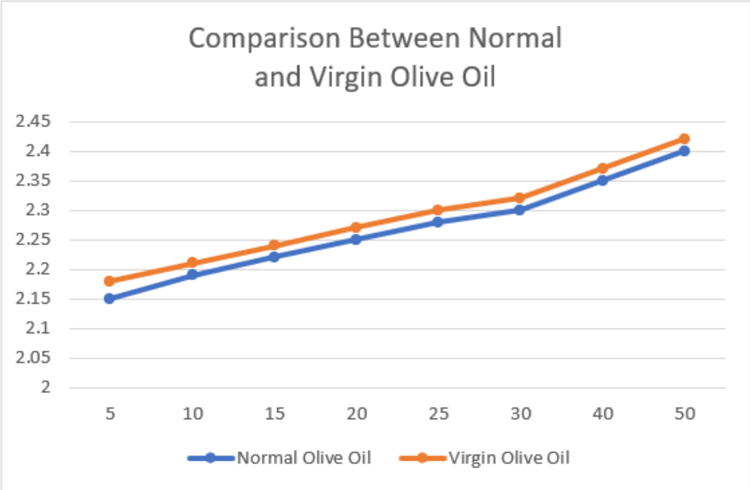


Fig. 5 *Comparison Between Normal and Virgin Olive Oil (Before Heat)*

Before heating, a distinctive comparison between normal olive oil and virgin olive oil reveals a consistent trend. Normal olive oil consistently exhibits higher permittivity values across various volumes compared to virgin olive oil. This difference underscores the superior dielectric properties of normal oil, suggesting better electrical conductivity or insulation capabilities. The inverse correlation between volume and permittivity is notable in both oil types, indicating that larger volumes result in higher electrical conductivity or a dilution effect within the oils. This observation emphasizes the importance of oil type and volume considerations in applications requiring specific electrical properties.

3.3.2 After Heating (at 70 Degree Celsius)

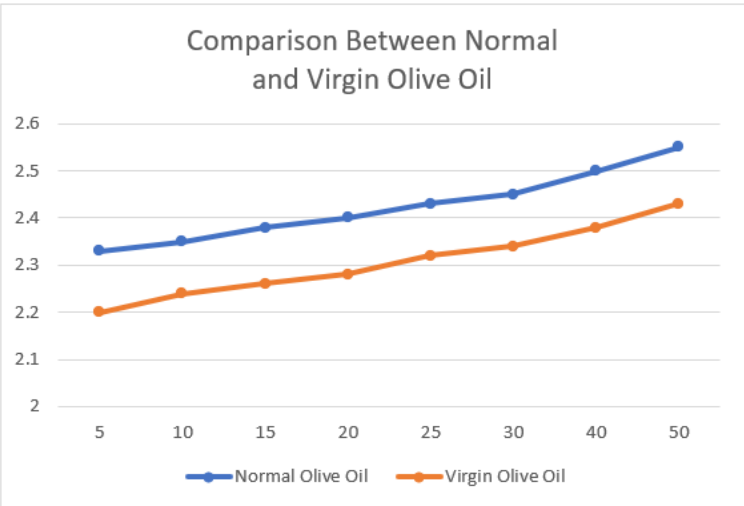


Fig. 6 *Comparison Between Normal and Virgin Olive Oil (After Heat)*

After heating, the comparison between normal olive oil and virgin olive oil continues to highlight distinct electrical characteristics. Both oils show an increase in permittivity values, suggesting alterations in their dielectric properties due to thermal treatment. Despite this common trend, normal olive oil consistently maintains higher permittivity values compared to virgin oil across all volumes tested. This persistent difference underscores the enduring superior dielectric properties of normal oil, making it a more favorable choice for electrical applications. The impact of temperature on permittivity emphasizes the need to consider thermal effects when assessing the suitability of these oils for specific electrical purposes.

4. Conclusion

In culmination, this research has delved into the realm of olive oil's electrical properties, with a specific focus on determining the relative permittivity of normal and virgin variants. The systematic experimental journey, encompassing sample preparation, precise calibration, and controlled measurements, has offered a nuanced understanding of the dielectric behaviors of these oils. The discerned patterns and variations in relative permittivity, both pre and post heating at 70 degrees Celsius, illuminate the distinct electrical characteristics of normal and virgin olive oil.[9] The consistent higher permittivity of normal oil across volumes and heating conditions implies superior dielectric properties, essential for various electrical applications. The project reveals similar trends pre- and post-heating, indicating the robustness of these oils in different conditions. Temperature's influence on the reduction of permittivity post-heating raises intriguing possibilities, suggesting structural alterations in the oils due to thermal treatment. The volume relationship, with consistent increases in permittivity, underscores the significant impact of volume on dielectric properties. In conclusion, this endeavor not only advances our scientific comprehension of olive oil's electrical behavior but also underscores the potential applications of these sustainable oils in electrical engineering domains. The consistent higher permittivity of normal olive oil positions it as a favorable choice for applications demanding enhanced electrical conductivity.[10] The findings herein contribute to the growing body of knowledge on alternative dielectric materials, fostering eco-conscious technological advancements. As we navigate the intersection of science and sustainability, this project serves as a steppingstone towards greener and more efficient electrical solutions, with olive oil emerging as a promising candidate in the landscape of dielectric materials.

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Conflict of Interest

The authors confirm the absence of any conflicts of interest in connection with the publication of this paper. They assert that there are no financial, personal, or professional affiliations that might introduce bias into their work, influence result interpretation, or compromise the objectivity of the research findings. This statement is provided to ensure transparency and uphold the research's integrity. It underscores that the authors have adhered to the highest ethical standards in their work and have conducted the research without any external influences that could potentially undermine the credibility of the scholarly contributions presented in the paper.

Author Contribution

The author affirms sole responsibility for key aspects of the research process, including the conception and design of the study, meticulous data collection, comprehensive analysis, and interpretation of results. Additionally, the author played a pivotal role in the preparation of the manuscript, ensuring clarity, coherence, and adherence to scholarly standards. This declaration of author contribution underscores the individual's active involvement in every phase of the research endeavor, from the initial conceptualization to the finalization of the manuscript. It attests to the author's dedication and leadership throughout the research process, highlighting their substantial role in shaping and executing the study with a high degree of autonomy and scholarly responsibility.

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