REVIEW

Why antioxidants typically exhibit anti-inflammatory action and the underlying biological mechanisms involved: a clinicobiological perspective

Ioannis Delimaris

PhD (ClinBiochem), MSc (ClinChem), BSc (BiolSc),PGCE, QTS, Post-Doc (Nutr), Registered College Lecturer (Reg Num 159/2013), Metropolitan College, Athens, Greece

ABSTRACT

This perspective article aims to elucidate the parameters behind the anti-inflammatory actions exhibited by antioxidants, along with the biological mechanisms involved. A brief narrative review was conducted, utilizing data retrieved from databases such as PubMed and Google Scholar with a focus on the key terms: antioxidants, anti-inflammatory action, and biological mechanisms. The perspective article highlights the interplay between oxidative stress and inflammation, clarifying that oxidative stress results from an imbalance of reactive oxygen species (ROS) and the body's antioxidant mechanisms. Furthermore, it demonstrates that antioxidants neutralize ROS, modulate inflammatory mediators, inhibit inflammatory enzymes, protect cellular integrity, regulate immune cell activity, and influence gene expression related to inflammation. Overall, the findings underscore the multifaceted roles of antioxidants in mitigating inflammatory processes. This understanding has significant implications for the development of therapeutic interventions aimed at enhancing antioxidant capacities to combat inflammation-related diseases.

Keywords: antioxidants, anti-inflammatory action, mechanisms, biology, medicine

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INTRODUCTION

Inflammation serves as a vital protective response, enabling the body to heal from injury and combat infection. However, when inflammation becomes chronic, it can propel the development of numerous diseases, including cardiovascular conditions and cancer. Given the detrimental effects of prolonged inflammatory states, understanding the modulatory roles of antioxidants in inflammation has garnered significant research attention [1-3]. This perspective article delves into the reasons why antioxidants are often associated with anti-inflammatory properties and the biological mechanisms that underpin this relationship. By examining relevant literature sourced from reputable databases such as PubMed and Google Scholar, this discussion will elucidate how antioxidants interact with inflammatory pathways,

highlighting their potential therapeutic implications. Through an analysis of existing studies, this article aims to shed light on the intricate interplay between oxidative stress, inflammation, and antioxidants, thereby providing insights for future research and clinical applications in managing inflammatory diseases.

Why Antioxidants Typically Exhibit Anti-Inflammatory Action and the Underlying Biological Mechanisms Involved

- **Oxidative Stress and Inflammation**

Oxidative stress represents a state of imbalance between reactive oxygen species (ROS) and the body's ability to detoxify or repair the resulting damage. This imbalance may consequently lead to cellular injury and eventual cell death. Importantly, ROS can activate specific signaling pathways that promote inflammation, notably the nuclear factor-kappa B (NF-κB) pathway. The activation of NF-κB leads to an increased expression of pro-inflammatory cytokines and various inflammatory mediators, amplifying the inflammatory response [4-5].

- **Scavenging Reactive Species**

One of the primary roles of antioxidants is their ability to neutralize ROS, which effectively reduces their levels and, thereby, diminishes the activation of inflammatory pathways. By scavenging these reactive species, antioxidants play a critical role in preventing the initiation of inflammatory responses, thereby providing a protective mechanism against chronic inflammation [6-7].

- **Modulation of Inflammatory Mediators**

Moreover, antioxidants significantly influence the production of cytokines and other mediators linked to inflammation. For instance, specific antioxidants have been documented to lower levels of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), while concurrently enhancing the production of anti-inflammatory cytokines like interleukin-10 (IL-10). This modulation serves as a crucial aspect of the anti-inflammatory effects of antioxidants [1, 8-9].

- **Inhibition of Inflammatory Enzymes**

Furthermore, certain antioxidants possess the ability to inhibit enzymes responsible for producing inflammatory mediators. Enzymes such as cyclooxygenase (COX) and lipoxygenase (LOX), which are involved in synthesizing prostaglandins and leukotrienes, respectively, can be inhibited by these antioxidants. This inhibition further contributes to reducing overall inflammatory activity [10-11].

- **Preventing Cell Damage**

By mitigating oxidative damage to cells and tissues, antioxidants assist in maintaining cellular integrity. Damaged cells tend to release pro-inflammatory signals that can exacerbate the inflammatory response. Hence, the protection provided by antioxidants against oxidative damage indirectly aids in the resolution of such responses [1-12].

- **Regulation of Immune Cells**

Additionally, antioxidants impact various immune cell activities, particularly macrophages. For example, antioxidants may facilitate the transition from a pro-inflammatory M1 macrophage phenotype to an anti-inflammatory M2 phenotype, thereby promoting the resolution of inflammation. This modulation of immune cell activity underscores the multifaceted roles that antioxidants play in inflammatory processes [13-14].

- **Influencing Gene Expression**

Lastly, some antioxidants are known to affect the expression of genes associated with inflammation and oxidative stress. For instance, they may activate nuclear transcription factors such as Nrf2, which has been found to upregulate the expression of antioxidant proteins while simultaneously downregulating genes that encode pro-inflammatory proteins. This dual regulation further elucidates the complex interplay between antioxidants and inflammatory mechanisms [15-16].

CONCLUSIONS

In conclusion, antioxidants exhibit substantial anti-inflammatory action through various biological mechanisms, including the scavenging of reactive species, modulation of inflammatory mediators, inhibition of inflammatory enzymes, protection against cellular damage, regulation of immune cell function, and influence on gene expression. These findings emphasize the potential therapeutic applications of antioxidants in mitigating chronic inflammatory diseases. Future research should continue to explore the breadth and nuances of these mechanisms to enhance our understanding and utilization of antioxidants in medical interventions.

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ΑΝΑΣΚΟΠΗΣΗ

Γιατί τα αντιοξειδωτικά παρουσιάζουν συνήθως αντιφλεγμονώδη δράση και οι εμπλεκόμενοι υποκείμενοι βιολογικοί μηχανισμοί: μια κλινικοβιολογική θεώρηση

Ιωάννης Δελημάρης

PhD (ClinBiochem), MSc (ClinChem), BSc (BiolSc), PGCE, QTS, Post-Doc (Nutr), Εγγεγραμμένος Διδάσκων Κολλεγίων (Αριθμός Μητρώου: 159/2013), Σχολή Επιστημών Υγείας, Μητροπολιτικό Κολλέγιο, Αθήνα, Ελλάδα

ΠΕΡΙΛΗΨΗ

Το παρόν άρθρο (κλινικοβιολογική θεώρηση) στοχεύει στο να διευκρινίσει τις παραμέτρους οι οποίες ενέχονται πίσω από τις αντιφλεγμονώδεις δράσεις που παρουσιάζουν τα αντιοξειδωτικά μόρια, μαζί με τους υφιστάμενους βιολογικούς μηχανισμούς οι οποίοι εμπλέκονται. Πραγματοποιήθηκε μια βραχεία περιγραφική ανασκόπηση, χρησιμοποιώντας δεδομένα που ανακτήθηκαν από βάσεις δεδομένων όπως το PubMed και το Google Scholar με έμφαση στους όρους ευρετηρίου: "αντιοξειδωτικά", "αντιφλεγμονώδης δράση" και "βιολογικοί μηχανισμοί". Το άρθρο υπογραμμίζει την αλληλεπίδραση μεταξύ οξειδωτικού στρες και φλεγμονής, διευκρινίζοντας ότι το οξειδωτικό στρες προκύπτει από μια ανισορροπία μεταξύ των ελευθέρων ριζών οξυγόνου (ROS) και των αντιοξειδωτικών μηχανισμών του οργανισμού. Επιπλέον, καταδεικνύει ότι τα αντιοξειδωτικά εξουδετερώνουν τις ROS, ρυθμίζουν τα μόρια-μεσολαβητές της φλεγμονής, καταστέλλουν την ενεργότητα των ενζύμων κυκλοοξυγενάση και λιποξυγενάση, προστατεύουν την κυτταρική ακεραιότητα, ρυθμίζουν τη δραστηριότητα των κυττάρων του ανοσοποιητικού και επηρεάζουν την έκφραση γονιδίων που σχετίζονται με τη φλεγμονή. Συμπερασματικά, τα ευρήματα υπογραμμίζουν τους πολύπλευρους ρόλους των αντιοξειδωτικών μορίων στον μετριασμό των φλεγμονωδών διεργασιών. Η κατανόηση των εμπλεκόμενων παραμέτρων δύναται να έχει σημαντικές επιπτώσεις στην ανάπτυξη θεραπευτικών παρεμβάσεων, οι οποίες στοχεύουν στην ενίσχυση των αντιοξειδωτικών μηχανισμών του οργανισμού για την καταπολέμηση ασθενειών σχετιζόμενων με τη φλεγμονή.

Λέξεις ευρετηρίου: αντιοξειδωτικά, αντιφλεγμονώδης δράση, μηχανισμοί, βιολογία, ιατρική

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Corresponding author: **Ioannis Delimaris,** E-mail: dr.i.delimaris@gmail.com