

Editorial

Bioactive Compounds and Functional Foods in Human Health—Bridging Mechanisms and Applications for Future Nutrition

Vassilis Athanasiadis *  and Stavros I. Lalas 

Department of Food Science and Nutrition, University of Thessaly, Terma N. Temponera Street, 43100 Karditsa, Greece; slalas@uth.gr

* Correspondence: vaathanasiadis@uth.gr

The role of bioactive compounds in the diet has moved from the periphery to the center of scientific and societal debate in both research and public health. Over the past decade, evidence has accumulated showing that polyphenols, carotenoids, and other bioactive molecules can influence inflammation, oxidative stress, and metabolic regulation. These findings are particularly important for chronic diseases such as cardiovascular disease and type 2 diabetes, where proper nutrition continues to act as an adjunct to medical therapy [1,2]. However, the benefits of these compounds are not guaranteed. Their efficacy depends on bioavailability, which is shaped by food structure and, increasingly, by interactions with the gut microbiota [1–3].

Despite this progress, many questions remain unanswered. We still lack a clear picture of how phytochemicals are absorbed and metabolized in real-world dietary contexts. Food matrices, preparation methods, and microbial interactions can alter outcomes in ways that are difficult to predict [2]. These uncertainties explain why clinical outcomes are sometimes inconsistent and highlight the need for more integrated approaches. Exploring these mechanisms is not only scientifically demanding, but also provides a foundation for translating laboratory data into realistic dietary practices [2,4].

The contributions to this Special Issue make important steps toward filling these gaps. Several publications examine how bioactive compounds interact with the microbiome [5], mitochondrial function [6], and lipid metabolism [7]. Together, they demonstrate a shift in the field—from isolated biochemical observations to a system-level understanding of nutrition. This approach is a necessary condition for the practical application of functional foods. A clear understanding of the mechanisms, especially biomolecular interactions, is essential for the reproducibility and clinical validity of the results [1,8].

Personalized nutrition is expected to be a central focus of future research and clinical activity. Genetic diversity, microbiome composition, and lifestyle factors all shape individual responses to nutrition. Although personalized nutrition is of particular interest, its implementation must be based on documented scientific and functional data [5,9]. Without a scientific basis, personalized nutrition may become a marketing fad rather than a meaningful therapeutic approach. Current research on nutrient–genotype interactions and microbiome-based nutritional strategies suggests that personalized recommendations could ultimately improve therapeutic outcomes [4,9,10].

The need for sustainable solutions makes it imperative to exploit alternative sources of bioactive compounds, such as neglected crops and agro-industrial by-products, placing nutritional research in the broader context of ecological responsibility. For example, olive



Received: 1 November 2025

Revised: 3 November 2025

Accepted: 5 November 2025

Published: 17 November 2025

Citation: Athanasiadis, V.; Lalas, S.I. Bioactive Compounds and Functional Foods in Human Health—Bridging Mechanisms and Applications for Future Nutrition. *Nutrients* **2025**, *17*, 3586. <https://doi.org/10.3390/nu17223586>

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

leaves and citrus peels—by-products of the olive oil and juice industries, respectively—have emerged as promising sources of polyphenols with antioxidant and anti-inflammatory properties [11,12]. Similarly, underutilized crops such as amaranth and *Moringa oleifera* offer bioactive profiles that support both nutritional and ecological goals [13]. Advances in extraction and processing will be crucial to ensure that functional foods contribute not only to human health but also to ecological resilience [14]. In parallel, regulatory frameworks need to evolve, aiming to establish internationally harmonized standards, so that functional foods can gain consumer trust and be widely integrated into the market [9]. Looking ahead, several challenges remain in translating mechanistic insights into actionable dietary recommendations. Key questions include how to account for individual variability in microbiome composition, how to ensure reproducibility across diverse populations, and how to integrate emerging molecular data into practical guidelines. Addressing these issues will require coordinated efforts across nutrition science, clinical research, and regulatory policy [15,16].

In conclusion, bioactive compounds and functional foods have significant potential, the exploitation of which requires, beyond laboratory documentation, interdisciplinary collaboration and applied research. The transition from theory to practice requires interdisciplinary synergy and institutional alignment, with particular attention to environmental and regulatory parameters. If these elements are aligned, functional nutrition could become one of the defining public health strategies of the coming decades.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Aydın, E. The Impact of Raisin Consumption on Quercetin Bioavailability: An In Vivo Approach In Vivo. *Gida J. Food* **2024**, *49*, 741–750. [\[CrossRef\]](#)
2. Bohn, T.; McDougall, G.J.; Alegría, A.; Alminger, M.; Arrigoni, E.; Aura, A.; Brito, C.; Cilla, A.; El, S.N.; Karakaya, S.; et al. Mind the Gap—Deficits in Our Knowledge of Aspects Impacting the Bioavailability of Phytochemicals and Their Metabolites—A Position Paper Focusing on Carotenoids and Polyphenols. *Mol. Nutr. Food Res.* **2015**, *59*, 1307–1323. [\[CrossRef\]](#) [\[PubMed\]](#)
3. Danesi, F.; Calani, L.; Valli, V.; Bresciani, L.; Rio, D.D.; Bordon, A. (Poly)phenolic Content and Profile and Antioxidant Capacity of Whole-Grain Cookies Are Better Estimated by Simulated Digestion Than Chemical Extraction. *Molecules* **2020**, *25*, 2792. [\[CrossRef\]](#) [\[PubMed\]](#)
4. Goñi, L.; Cuervo, M.; Milagro, F.I.; Martínéz, J.A. Future Perspectives of Personalized Weight Loss Interventions Based on Nutrigenetic, Epigenetic, and Metagenomic Data. *J. Nutr.* **2016**, *146*, 905S–912S. [\[CrossRef\]](#) [\[PubMed\]](#)
5. Zancarini, A.; Signor, C.L.; Terrat, S.; Aubert, J.; Salon, C.; Munier-Jolain, N.; Mougél, C. Medicago Truncatula Genotype Drives the Plant Nutritional Strategy and Its Associated Rhizosphere Bacterial Communities. *New Phytol.* **2024**, *245*, 767–784. [\[CrossRef\]](#) [\[PubMed\]](#)
6. Zancarini, A.; Mougél, C.; Voisin, A.-S.; Prudent, M.; Salon, C.; Munier-Jolain, N. Soil Nitrogen Availability and Plant Genotype Modify the Nutrition Strategies of M. Truncatula and the Associated Rhizosphere Microbial Communities. *PLoS ONE* **2012**, *7*, e47096. [\[CrossRef\]](#) [\[PubMed\]](#)
7. O'Brien, A.; Laurich, J.R.; Frederickson, M.E. Having the 'Right' Microbiome Matters for Host Trait Expression and the Strength of Mutualism Between Duckweeds and Microbes. *bioRxiv* **2022**. [\[CrossRef\]](#)
8. Hamonts, K.; Trivedi, P.; Garg, A.; Janitz, C.; Grinyer, J.; Holford, P.; Botha, F.C.; Anderson, I.C.; Singh, B.K. Field Study Reveals Core Plant Microbiota and Relative Importance of Their Drivers. *Environ. Microbiol.* **2018**, *20*, 124–140. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Celis-Morales, C.; Livingstone, K.M.; Marsaux, C.F.M.; Macready, A.L.; Fallaize, R.; O'Donovan, C.B.; Woolhead, C.; Forster, H.; Walsh, M.C.; Navas-Carretero, S.; et al. Effect of Personalized Nutrition on Health-Related Behaviour Change: Evidence from the Food4me European Randomized Controlled Trial. *Int. J. Epidemiol.* **2017**, *46*, 578–588. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Song, E.; Shin, J. Personalized Diets Based on the Gut Microbiome as a Target for Health Maintenance: From Current Evidence to Future Possibilities. *J. Microbiol. Biotechnol.* **2022**, *32*, 1497–1505. [\[CrossRef\]](#) [\[PubMed\]](#)
11. Athanasiadis, V.; Grigorakis, S.; Lalas, S.; Makris, D.P. Highly Efficient Extraction of Antioxidant Polyphenols from *Olea europaea* Leaves Using an Eco-friendly Glycerol/Glycine Deep Eutectic Solvent. *Waste Biomass Valor.* **2018**, *9*, 1985–1992. [\[CrossRef\]](#)
12. Athanasiadis, V.; Chatzimitakos, T.; Mantiniotou, M.; Bozinou, E.; Lalas, S.I. Exploring the Antioxidant Properties of *Citrus limon* (Lemon) Peel Ultrasound Extract after the Cloud Point Extraction Method. *Biomass* **2024**, *4*, 202–216. [\[CrossRef\]](#)

13. Wani, S.A. Utilization of Underutilized Vegetables. In *Sustainable Plant Foods*; Academic Press: Cambridge, MA, USA, 2025; pp. 97–110, ISBN 978-0-443-31652-4.
14. Lailheugue, V.; Darriaut, R.; Tran, J.; Morel, M.; Marguerit, E.; Lauvergeat, V. Both the Scion and Rootstock of Grafted Grapevines Influence the Rhizosphere and Root Endophyte Microbiomes, but Rootstocks Have a Greater Impact. *Environ. Microbiome* **2024**, *19*, 24. [[CrossRef](#)] [[PubMed](#)]
15. Rashidinejad, A. The road ahead for functional foods: Promising opportunities amidst industry challenges. *Future Postharvest Food* **2024**, *1*, 266–273. [[CrossRef](#)]
16. Phung, N.T.K.; Anh, N.C.H.; Thy, N.Q.; Anh, T.P.P.; Vinh, V.M.; Nhu, L.N.H. Economic Implications of Biotech-Driven Functional Foods: The Role of Consumer Trust and Scientific Validation, Moderated by Health Awareness. *J. Econ. Financ. Manag. Stud.* **2025**, *08*, 6360–6373. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.