F. CHEMICAL & FOOD ENGINEERING

F.1. ENTROPY CONTROL IN THE PROLONGATION OF FUNCTIONAL PROPERTIES OF BIOLOGICALLY ACTIVE COMPOUNDS IN FOOD COMPOSITIONS

ALEXEI BAERLE*

Technical University of Moldova, 168 Stefan cel Mare Blvd., Chisinau, Republic of Moldova
email: alexei.baerle@chim.utm.md

Abstract. The prolongation of functional properties of biologically active compounds (BAC) in food systems is limited by oxidative degradation, structural disorganization, unfavorable interfacial interactions, and other spontaneous transformations that develop during processing and storage under non-equilibrium conditions. In the present work, BAC preservation is interpreted as a problem of entropy control in multicomponent food systems. Functional instability is considered not as an isolated chemical event, but as a manifestation of systemic disordering at molecular, supramolecular, and microstructural levels. Accordingly, prolongation of BAC functionality is achieved through technological strategies that restrict entropy growth, reduce destabilizing degrees of freedom, and maintain ordered states resistant to degradation over time.

This concept was validated in a range of food compositions and model systems. High-molecular biopolymers, including alginate and arabinoxylan, were developed as stabilizing matrices for BAC. Their effect proved to be system-specific: some polymers destabilized anthocyanins in aqueous media, whereas betanin stabilization appeared above threshold concentrations, for example at more than 0.03% hyaluronic acid. Quinochalcone pigment Carthamine and Isocarthamine, intrinsically unstable in water, were transferred into a more ordered state through cellulose complexation, which significantly expanded their applicability in high-moisture and acidolactic systems (pH 4…6). In lipid-containing systems, entropy control was expressed through antioxidant synergy and structural regulation of dispersed phases, yielding a 20…40% decrease in degradation rates of ω3 and ω6-rich lipids. In dispersed food matrices, stabilization correlated with structural compactness and low polydispersity; in particular, PDI values below 0.2 corresponded to more stable states of oil-containing edible microcapsules. In multiphase systems of the oil/water/air type, the effect of structuring was non-linear: excessive dispersion increased the entropic cost of stabilization, whereas controlled organization of interfaces improved functional retention. The interfacial scale of such systems reached $10^4…10^5$ $m^2·kg^{-1}$, confirming the decisive role of structural organization in BAC stability.

Thus, the prolongation of BAC functionality should be regarded not only as a compositional or kinetic task, but also as a structural-thermodynamic one. Selective removal of destabilizing compounds, synergistic antioxidant action, complexation with edible biopolymers, and purposeful micro-structuring act as entropy-control strategies that promote the transition from disordered, degradation-prone states to more ordered and functionally stable ones. Entropy control therefore emerges as a unifying principle for the design of food compositions with prolonged functional stability and predictable technological performance.

Keywords: BACs; biopolymers; entropy control; functional stability; interfacial processes.

Acknowledgments: This work was supported by the ANCD-governed institutional project, subprogram 020405, “Optimizing Food Processing Technologies in the Context of the Circular Bioeconomy and Climate Change” (Bio-OpTehPAS), implemented at the Technical University of Moldova.