coatings

Editorial

Special Issue: Coatings and Thin Films as Functional and Protective Structures in Food Technology and Their Potential in Packaging Applications

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One of the main challenges of the modern world is coping with the problem of antibiotic resistance. This constitutes a serious threat not only in medicine but also in the food industry [1,2]. It has been shown many times that microorganisms isolated from food are characterized by antibiotic resistance, which indicates the difficulty in eliminating bacteria from the food processing environment [3–5]. An additional factor hindering the maintenance of the microbiological safety of food is the presence of bacteria in biofilms—as complex structures surrounded by a layer of extracellular matrix, their antimicrobial tolerance is up to a thousand times greater than a single bacterium [6]. The elimination of foodborne pathogens is also problematic because consumers expect food to be as natural as possible, with a simple composition and without additives, improvers or other unnecessary chemicals. This limits the spectrum of antibacterial substances that can be used in food [7].

Therefore, there is an urgent need to find substances that ensure the microbiological safety of food and, at the same time, minimize the use of synthetic preservatives, thus ensuring effective antibacterial protection and consumer acceptance. In this respect, two dominant trends are observed—the use of natural antimicrobials (mainly essential oils and plant extracts) and the use of antagonistic interactions between microorganisms, e.g., the activity of probiotic strains against pathogenic bacteria [8,9]. In addition, it has been proposed that we abandon the use of antimicrobial substances directly in food, and that we instead use coatings, casings, and packaging to counteract pathogenic bacteria that spoil food or cause microbiological defects in food. This approach slightly extends the panel of possible antimicrobials to include, e.g., polymers and nanomaterials. As these antimicrobials are not directly contained in the food product, they are more acceptable to consumers [10].

The potential of natural antibacterial substances as well as polymers and nanomaterials has been demonstrated in previous studies. Firstly, the antibacterial potential of essential oils (EOs) has been studied extensively. For instance, Mahdavi et al. [11] investigated the effect of EOs from rhizomes, stems and leaves of *Etlingera sayapensis* and showed that these oils inhibited the growth of microorganisms. Moreover, they showed that EO from rhizomes had the widest spectrum of activity, inhibiting the growth of both Gram-positive and Gram-negative bacteria [11]. In another study, Oh et al. [12] investigated the antimicrobial activity of blended EOs and single EOs, i.e., oregano, thymol, and cavacrol, against biofilms of *Escherichia coli* and *Salmonella*. It was shown that variants of both EOs caused the damage of the biofilm surface. Additionally, this study showed that thymol and oregano had higher antimicrobial properties against *E. coli* than carvacrol, while carvacrol and thymol had higher antimicrobial potential against *Salmonella* than oregano [12]. Secondly, natural substances also have proven antibacterial properties. For instance, Lu et al. [13] evaluated the antibiofilm properties of cinnamon extract against *Vibrio parahaemolyticus* and *E. coli*. The results showed that the extract had high antimicrobial properties, reduced metabolic activity, and inhibited extracellular polysaccharide (EPS) secretion [13]. In another study, Famuyide et al. [14] evaluated the acetone leaf extracts of Eugenia and Syzygium in the context of their antimicrobial and antibiofilm properties. It was shown that Syzygium extracts had a wide spectrum of activity, showing effectiveness against Gram-positive and Gram-negative bacteria, while the Eugenia extract had high activity against *Bacillus cereus* [14]. Thirdly, there are also studies linking the antibacterial properties of natural substances with the potential of nanoparticles. For instance, Jeong et al. [15] investigated the antimicrobial activity of cinnamon essential oil nanoemulsion against multi-species biofilm and showed that this nanoemulsion inhibited the maturation of combined biofilms. Moreover, the application of nanoparticles from precious metals successfully limited bacterial growth. For instance, in the study by Korzekwa et al. [16], the researchers assessed the effect of silver nanoparticles (AgNPs) immobilized on SiO2 or TiO2 on biofilm formation by *P. aeruginosa*. It was shown that immobilized AgNPs had high efficacy against the planktonic and biofilm forms of *P. aeruginosa*, indicating that inorganic compounds (SiO2, TiO2) enriched with nanoparticles can be used as antimicrobials against *P. aeruginosa* [16]. An interesting study was conducted by Lotha et al. [17]. This study compared the antibacterial properties of AgNPs obtained from purified nutraceuticals (quercetrin and afzelin) of the *Crotolaria tetragona* with chemically synthesized AgNPs. It was shown that plant-derived AgNPs had bacteriostatic and bactericidal properties against *P. aeruginosa* and *Salmonella enterica* serovar Typhi (*S. Typhi*). This study also showed that plant-derived AgNPs had potent antibiofilm properties against *S. Typhi*. Moreover, the plant-derived AgNPs decreased the hydrophobicity of the cell surface, limited adherence to the surface, as well as were less toxic and more effective against *S. Typhi* [17]. Fourth, polymer compounds are also used successfully as an antibacterial tool. For instance, Demir et al. [18] modified the stainless steel surface with N-halamine-based copolymer. The covalent binding of the synthesized copolymer to the stainless steel surface made it possible to obtain antibacterial surfaces. Furthermore, this surface had a high stability and durability and had resistance to washing and UVA radiation. The antimicrobial potential of the stainless steel copolymer used to coat surfaces was expressed in 6-log units reduction of *S. aureus* and *E. coli* O157: H7 cells within 15 min [18]. This finding showed the possibility of surface modification as an approach to enhance the anti-adhesion properties of the surface.

The research studies cited indicate the high antibacterial potential of natural substances, essential oils, plant extracts, nanoparticles, and polymers. In order to meet the expectations of consumers focused on natural food, it seems reasonable to use the potential of these substances to cover food and/or add them to packaging in order to ensure the microbiological safety of food.

Therefore, we encourage you to publish in this Special Issue the results of research or reviews offering new insight into natural coatings in food technology, recent discoveries of natural substances in shaping microbiological food safety, the potential of biological coatings and films in the production of packaging, and the role of natural coatings in increasing the nutritional value of food products. We believe that knowledge in this field is important and offers an interesting direction for scientific research with a high potential for real-world application in the food industry.

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