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Pubblicazione bimestrale in cui sono presentati 7 articoli multidisciplinari, afferenti al packaging, selezionati da diverse riviste del mondo scientifico digitale.

*Packaging Science attraverso le tematiche sempre attuali ed aggiornate dei suoi articoli in diverse discipline, concorre ampiamente alla promozione e all'evoluzione della corretta cultura del packaging e dei **10 Valori della Carta Etica** per accompagnare il packaging verso un futuro più consapevole.*

Strategia di utilizzo sostenibile dei rifiuti organici attraverso la fabbricazione di bioelastomero con attività antibatteriche e antiossidanti utilizzando estratti di buccia di mandarino

Le bucce di mandarino (MP), un residuo della lavorazione degli alimenti, hanno diverse restrizioni sul loro smaltimento e possono causare un grave inquinamento ambientale. In questo studio, MP è stato utilizzato per fabbricare un bioelastomero funzionale con attività antiossidanti e antibatteriche. I composti bioattivi sono stati recuperati da MP in forma liquida e aggiunti al bioelastomero durante la fabbricazione per mantenere la resistenza meccanica del bioelastomero. Si prevede che il bioelastomero fabbricato con attività antibatteriche e antiossidanti sarà utilizzato nell'industria degli imballaggi alimentari, farmaceutica e medica.



Article

Sustainable Utilization Strategy of Organic Waste via Fabrication of Bioelastomer with Antibacterial and Antioxidant Activities Using Mandarin Peel Extracts

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Abstract: Mandarin peels (MPs), a food-processing residue, have several restrictions on their disposal and can cause serious environmental pollution. In this study, MP was used to fabricate a functional bioelastomer with antioxidant and antibacterial activities. Bioactive compounds were recovered from MPs in liquid form and added to the bioelastomer during fabrication to maintain the mechanical strength of the bioelastomer. The radical scavenging activities of the fabricated bioelastomer (B-MPE 15%) were 3.3% for DPPH and 20.8% for ABTS, respectively. In addition, B-MPE 15% exhibited antibacterial activity against gram-positive (*Staphylococcus aureus*), gram-negative (*Escherichia coli*), and antibiotic-resistant bacteria (Methicillin-resistant *S. aureus* and Vancomycin resistant *Enterococcus*). The chemical properties of B-MPE 15% were not significantly different from those of the control group (bare PDMS). Tensile strength, elongation at break, and water vapor transmission rate of B-MPE 15% were found to be 5.1 N/mm², 649%, and 33.3 g/(m² day), respectively. Therefore, the addition of MP extracts did not significantly affect the physical properties. The fabricated bioelastomer with antibacterial and antioxidant activities is expected to be utilized in the food packaging, pharmaceutical, and medical industries. Our research is expected to represent a future-oriented strategy for realizing carbon neutrality by upcycling food waste.

Keywords: bioelastomer; mandarin peel; flavanone; antioxidant; antibacterial



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Estensione della durata di conservazione degli alimenti ad alto contenuto di grassi dall'ossidazione lipidica e dalla contaminazione microbiologica: un approccio che utilizza l'imballaggio attivo con l'estratto di melograno

La ricerca di nuove forme per prolungare la shelf-life degli alimenti attraverso l'uso di composti ed estratti naturali continua a crescere tra i ricercatori e l'industria. In questa linea di pensiero, l'obiettivo principale di questo lavoro è stato quello di sviluppare, caratterizzare e valutare l'efficacia di un packaging alimentare attivo a base di acido polilattico (PLA) e incorporato con estratti naturali ottenuti da sottoprodotti dell'uva e/o del melograno. In vitro, sono stati applicati metodi antiossidanti per valutare la capacità antiossidante di tre estratti: estratto di mosto, estratto di bucce di melograno liofilizzato (PPE-FD) e bucce di melograno naturale (PPE-N). La punicalagina (A + B) e l'acido ellagico sono stati determinati in PPE-FD, PPE-N e film attivi mediante UHPLC-DAD. Sono stati sviluppati nuovi imballaggi attivi basati su PLA con BUCCE DI RAME-FD (PLA/3PPE) e melograno (PLA/3PP) e sono state valutate le loro proprietà chimiche, meccaniche e barriera.



Article

Extending High Fatty Foods Shelf-Life from Lipid Oxidation and Microbiological Contamination: An Approach Using Active Packaging with Pomegranate Extract

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Abstract: The search for new forms to extend foodstuffs' shelf-life through the use of natural compounds and extracts continues to grow among researchers and the industry. In this line of thought, the main objective of this work was to develop, characterize and evaluate the effectiveness of an active food packaging based on polylactic acid (PLA) and incorporated with natural extracts obtained from grape and/or pomegranate by-products. In vitro, antioxidant methods were applied to evaluate the antioxidant capacity of these extracts: wort extract, in-situ-dried pomegranate peels extract (PPE-FD), and natural pomegranate peels (PPE-N). Punicalagin (A + B) and ellagic acid were determined in PPE-FD, PPE-N, and active films by UHPLC-DAD. New PLA-based active packaging with PPE-FD (PLA/3PPE) and pomegranate peels (PLA/3PP) were developed, and their chemical, mechanical, and barrier properties were evaluated. Moreover, the effectiveness of the new film was carried out through the study of lipid oxidation state and microbial contamination of two high-fat content foodstuffs: almonds and beef meat. PPE-FD presented high antioxidant capacity and high content

Valutazione della qualità e della shelf-life della carne bovina fresca conservata in imballaggi intelligenti

La carne bovina è un prodotto alimentare deperibile suscettibile di deterioramento a causa della crescita microbica. Pertanto, questo studio mirava ad accertare le prestazioni del confezionamento attivo e intelligente monitorando il cambiamento nella qualità della carne bovina fresca conservata a basse temperature. Il metodo di confezionamento intelligente ha utilizzato indicatori con soluzioni di Bromo Phenol Blue (BPB) e Phenol Red (PR) per monitorare il cambiamento nella qualità della carne bovina. Inoltre, l'imballaggio attivo utilizzava estratto di aglio con varie concentrazioni allo 0%, 15% e 20% per mantenere la qualità della carne bovina confezionata a temperature di 10 ° C. Ciò è stato indicato da un cambiamento nel colore dell'indicatore dal giallo scuro all'arancione e al rosso, sfumando in viola.



Technical Note

Quality and Shelf-Life Evaluation of Fresh Beef Stored in Smart Packaging

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Abstract: Beef is a perishable food product susceptible to deterioration due to microbial growth. Therefore, this study aimed to ascertain how active and intelligent packaging performs by tracking the change in the quality of fresh beef stored at low temperatures. The intelligent packaging method employed indicators with solutions of Bromo Phenol Blue (BPB) and Phenol Red (PR) to monitor the change in beef quality. Additionally, active packaging used garlic extract with various concentrations at 0%, 15%, and 20% to maintain the quality of beef packaged at 10 °C temperatures. The findings illustrated that a packaging indicator label can be implemented to monitor the change in the quality of fresh beef stored at 10 °C temperatures. This was signified by a change in the indicator color from dark yellow to orange and red, fading to purple. Meanwhile, observations on active packaging demonstrated that 15% and 20% of garlic extract were the most effective approaches for preserving beef quality. The correlation level of indicator label color analysis and the effectiveness of active packaging with all beef spoilage metrics demonstrated a positive correlation in preserving quality and identifying the degree of beef damage. Therefore, these active and intelligent packaging indicators can be applied to monitor and retain the quality of packaged beef.

Keywords: garlic extract; packaging indicators; packaged beef

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Un materiale di imballaggio alimentare attivo a base biologica di ZnO@Plant polifenoli / cellulosa / alcol polivinilico: PROGETTAZIONE, caratterizzazione e applicazione

I materiali di imballaggio attivi proteggono gli alimenti dal deterioramento e ne prolungano la durata. Nel tentativo di progettare materiali di imballaggio intriganti, ZnO biocomposito / polifenoli vegetali / cellulosa / alcol polivinilico (ZnPCP) è stato preparato tramite semplici metodi idrotermali e di fusione. La struttura e la morfologia del composito sono state completamente analizzate utilizzando XRD, FTIR, SEM e XPS. Le particelle di ZnO, i polifenoli vegetali (PPL) e la cellulosa sono risultati dispersi nel PVA. Tutti questi componenti condividono le loro funzioni uniche con le proprietà del composito.



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Article

An Active Bio-Based Food Packaging Material of ZnO@Plant Polyphenols/Cellulose/Polyvinyl Alcohol: DESIGN, Characterization and Application

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Abstract: Active packaging materials protect food from deterioration and extend its shelf life. In the quest to design intriguing packaging materials, biocomposite ZnO/plant polyphenols/cellulose/polyvinyl alcohol (ZnPCP) was prepared via simple hydrothermal and casting methods. The structure and morphology of the composite were fully analyzed using XRD, FTIR, SEM and XPS. The ZnO particles, plant polyphenols (PPL) and cellulose were found to be dispersed in PVA. All of these components share their unique functions with the composite's properties. This study shows that PPL in the composite not only improves the ZnO dispersivity in PVA as a crosslinker, but also enhances the water barrier of PVA. The ZnO, PPL and cellulose work together, enabling the biocomposite to perform as a good food packaging material with only a 1% dosage of the three components in PVA. The light shielding investigation showed that ZnPCP-10 can block almost 100% of both UV and visible light. The antibacterial activities were evaluated by Gram-negative *Escherichia coli* (*E. coli*) and Gram-positive *staphylococcus aureus* (*S. aureus*), with 4.4 and 6.3 mm inhibition zones, respectively, being achieved by ZnPCP-10. The enhanced performance and easy degradation enables the biocomposite ZnPCP to be a prospect material in the packaging industry.



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An Active Bio-Based Food Packaging

Keywords: plant polyphenol; cellulose; PVA film; zinc oxide; UV shielding; antibacterial activity

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Microplastiche derivate dai rifiuti di imballaggio alimentare: origine e rischi per la salute

Le materie plastiche sono comunemente utilizzate per l'imballaggio nell'industria alimentare. I materiali termoplastici più popolari che hanno trovato tali applicazioni sono polietilene (PE), polipropilene (PP), poli(etilene tereftalato) (PET) e polistirene (PS). Sfortunatamente, la maggior parte degli imballaggi in plastica è usa e getta. Di conseguenza, vengono generate quantità significative di rifiuti, che entrano nell'ambiente e subiscono processi di degrado. Possono verificarsi sotto l'influenza di forze meccaniche, temperatura, luce, fattori chimici e biologici. Questi fattori possono presentare effetti sinergici o antagonisti. Come risultato della loro azione, si formano microplastiche, che possono subire ulteriore frammentazione e decomposizione in composti a piccole molecole.



Review

Microplastics Derived from Food Packaging Waste—Their Origin and Health Risks

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Abstract: Plastics are commonly used for packaging in the food industry. The most popular thermoplastic materials that have found such applications are polyethylene (PE), polypropylene (PP), poly(ethylene terephthalate) (PET), and polystyrene (PS). Unfortunately, most plastic packaging is disposable. As a consequence, significant amounts of waste are generated, entering the environment, and undergoing degradation processes. They can occur under the influence of mechanical forces, temperature, light, chemical, and biological factors. These factors can present synergistic or antagonistic effects. As a result of their action, microplastics are formed, which can undergo further fragmentation and decomposition into small-molecule compounds. During the degradation process, various additives used at the plastics' processing stage can also be released. Both microplastics and additives can negatively affect human and animal health. Determination of the negative consequences of microplastics on the environment and health is not possible without knowing the course of degradation processes of packaging waste and their products. In this article, we present the sources of microplastics, the causes and places of their formation, the transport of such particles, the degradation of plastics most often used in the production of packaging for food storage, the factors affecting the said process, and its effects.



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Keywords: polymer; plastic; waste; degradation; microplastic; nanoplastic; environment pollution; food safety; human health

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La modellazione della migrazione come valido strumento per la valutazione dell'esposizione e la caratterizzazione del rischio di oligomeri di PET

Il polietilene tereftalato (PET) è uno dei materiali a contatto con gli alimenti più utilizzati grazie alle sue eccellenti proprietà meccaniche e alla riciclabilità. La migrazione delle sostanze dal PET e la valutazione della conformità sono solitamente determinate da test sperimentali, che possono essere difficili a seconda dei migranti di interesse. Basse concentrazioni e standard di riferimento mancanti, tra gli altri fattori, hanno portato a indagini inadeguate sul potenziale di migrazione degli oligomeri PET. La modellazione della migrazione può superare tali limitazioni ed è quindi un punto di partenza adeguato per l'esposizione e la valutazione del rischio. In questo studio, l'attivazione basata sull'energia (EA) e il modello AP sono stati utilizzati per valutare sistematicamente il potenziale di migrazione di 52 oligomeri PET per 12 diversi scenari applicativi.



Article

Migration Modeling as a Valuable Tool for Exposure Assessment and Risk Characterization of Polyethylene Terephthalate Oligomers

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Abstract: Polyethylene terephthalate (PET) is one of the most widely used food contact materials due to its excellent mechanical properties and recyclability. Migration of substances from PET and assessment of compliance are usually determined by experimental testing, which can be challenging depending on the migrants of interest. Low concentrations and missing reference standards, among other factors, have led to inadequate investigation of the migration potential of PET oligomers. Migration modeling can overcome such limitations and is therefore a suitable starting point for exposure and risk assessment. In this study, the activation energy-based (E_A) model and the AP model were used to systematically evaluate the migration potential of 52 PET oligomers for 12 different application scenarios. Modeling parameters and conditions were evaluated to investigate their impact and relevance on the assessment of realistic exposures. Obtained results were compared with safety thresholds known from the concept of toxicological thresholds of concern. This allowed the evaluation and identification of oligomers and/or applications where migration or exposure levels may be associated with a potential risk because they exceed these safety thresholds. Overall, this study demonstrated that migration modeling can be a high-throughput, fast, flexible, and suitable approach for comprehensive exposure assessment.

Keywords: migration modeling; food contact material; food packaging; polyethylene terephthalate; oligomer; exposure assessment; risk assessment



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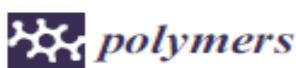
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Miglioramento delle macroparticelle di prodotti di scarto del caffè nei materiali biopolimerici per imballaggi commestibili

L'inquinamento da plastica ha suscitato interesse per alternative plastiche biodegradabili e sostenibili. Per il confezionamento alimentare commestibile, i biopolimeri di alghe marine sono stati studiati per le loro proprietà filmogene. In questo studio, i film di imballaggio sono stati sviluppati utilizzando la tecnica di colata con solvente da alghe rosse naturali (*Kappaphycus alvarezii*) e prodotti di scarto del caffè. Le proprietà fisico-chimiche e termiche dei film biopolimerici di alghe/caffè sono state ottenute utilizzando la diffusione dinamica della luce (DLS), la microscopia elettronica a scansione (SEM), l'irradiazione a trasmissione di Fourier (FT-IR), la misurazione dell'angolo di contatto con l'acqua (WCA) e l'analisi termogravimetrica (TGA). Lo studio di caratterizzazione è stato effettuato per migliorare le proprietà morfologiche, termiche e meccaniche del film.



Article

Coffee Waste Macro-Particle Enhancement in Biopolymer Materials for Edible Packaging

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Abstract: Plastic pollution has raised interest in biodegradable and sustainable plastic alternatives. For edible food packaging, seaweed biopolymers have been studied for their film-forming properties. In this study, packaging films were developed using the solvent casting technique from natural red seaweed (*Kappaphycus alvarezii*) and coffee waste product. The physico-chemical and thermal properties of seaweed/coffee biopolymer films was obtained using dynamic light scattering (DLS), scanning electron microscopy (SEM), Fourier transmission irradiation (FT-IR), water contact angle measurement (WCA) and thermogravimetric analysis (TGA). The characterization study was carried out to improve the film's morphological, thermal, and mechanical properties. The average particle size of coffee waste was found to be between 1.106 and 1.281 μm , with a zeta potential value of -27.0 mV indicating the compound's strong negative charge. The SEM analysis revealed that the coffee filler was evenly dispersed in the polymer matrix, improving the film's structural properties. The FT-IR result shows that coffee waste was successfully incorporated over the film matrix with the presence of a N-H bond. The hydrophobic property of the film was enhanced with the incorporation of coffee filler, indicating increased water contact angle compared to the neat film. The tensile properties of the biopolymer film were significantly improved at 4 wt% coffee powder with optimum tensile strength (35.47 MPa) with the addition of coffee waste powder. The incorporation of coffee waste into the seaweed matrix increased the functional properties of the fabricated biopolymer film. Thus, seaweed/coffee biopolymer film has the potential to be used in food packaging and other applications.

Keywords: coffee waste; seaweed; biopolymer film; edible film; food packaging



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