

NUMERO 1 - GENNAIO 2025

PACKAGING SCIENCE

*E' la Rassegna Scientifica Internazionale della **Fondazione Carta Etica del Packaging**.*

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.*

Poliidrossialcanoati (PHA): approfondimenti meccanicistici e contributi alle pratiche sostenibili

Negli ultimi due secoli, c'è stato un aumento significativo della produzione e dell'uso globali di materie plastiche a base petrolchimica. Questa impennata ha portato a diffusi squilibri ecologici, che hanno colpito la qualità dell'aria, gli ecosistemi terrestri e marini, le catene alimentari e la vita vegetale. Di conseguenza, l'uso eccessivo di tali polimeri ha creato sfide nella gestione dei rifiuti solidi, con metodi come la bio o fotodegradazione, l'incenerimento, lo smaltimento in discarica e il riciclaggio che si sono rivelati dispendiosi in termini di tempo e laboriosi. Pertanto, c'è una crescente urgenza di polimeri biodegradabili a causa della crescente domanda. Questo studio fornisce una panoramica sistematica dei PHA, compresa la loro classificazione, il contesto storico, i metodi di produzione, le potenziali sfide per la commercializzazione e le diverse applicazioni.



Entry

Polyhydroxyalkanoates (PHAs): Mechanistic Insights and Contributions to Sustainable Practices

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Definition: A polymer is a long-chain molecule formed by linking numerous simpler repeating chemical units, known as monomers, with identical structures. Over the past two centuries, there has been a significant increase in the global production and use of petrochemical-based plastics. This surge has led to widespread ecological imbalances, affecting air quality, terrestrial and marine ecosystems, food chains, and plant life. Consequently, the excessive use of such polymers has created challenges in solid waste management, with methods like bio- or photo-degradation, incineration, landfilling, and recycling proving to be time-consuming and laborious. Therefore, there is a growing urgency for biodegradable polymers due to increasing demand. Biodegradable polymers consist of interconnected monomers with unstable links in the backbone, facilitated by various functional groups. Throughout the degradation process of these polymers, numerous biologically acceptable molecules are produced. This study examines the significance of biopolymers over petroleum-based counterparts, offering a detailed analysis. It is noteworthy that within the spectrum of biodegradable polymers, polyhydroxyalkanoates (PHAs) emerge as exceptionally promising candidates for substituting petroleum-derived polymers, owing to their remarkable physical attributes. Therefore, this study provides a systematic overview of PHAs, including their classification, historical background, methods of production, potential challenges to commercialization, and diverse applications.



Produzione di imballaggi alimentari flessibili a base di amido nei paesi in via di sviluppo: analisi dei processi, delle sfide e dei requisiti

Gli imballaggi biodegradabili offrono una soluzione conveniente e sostenibile all'inquinamento globale, in particolare nei paesi in via di sviluppo con infrastrutture di riciclaggio limitate. L'amido è adatto per sviluppare confezioni biodegradabili per alimenti grazie alla sua ampia disponibilità e al processo di produzione semplice e a bassa tecnologia. Sebbene lo sviluppo di imballaggi a base di amido sia ben documentato, la maggior parte degli studi si concentra sulle fasi di laboratorio della formulazione e della plastificazione, lasciando lacune nella comprensione di fasi chiave come il condizionamento delle materie prime, lo stampaggio su scala industriale, i processi di post-produzione e lo stoccaggio. Questo lavoro valuta la catena del valore degli imballaggi a base di amido nei paesi in via di sviluppo.



Review

Production of Starch-Based Flexible Food Packaging in Developing Countries: Analysis of the Processes, Challenges, and Requirements

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Abstract: Biodegradable packaging offers an affordable and sustainable solution to global pollution, particularly in developing countries with limited recycling infrastructure. Starch is well suited to develop biodegradable packages for foods due to its wide availability and simple, low-tech production process. Although the development of starch-based packaging is well documented, most studies focus on the laboratory stages of formulation and plasticization, leaving gaps in understanding key phases such as raw material conditioning, industrial-scale molding, post-production processes, and storage. This work evaluates the value chain of starch-based packaging in developing countries. It addresses the challenges, equipment, and process conditions at each stage, highlighting the critical role of moisture resistance in the final product's functionality. A particular focus is placed on replacing single-use plastic packaging, which dominates food industries in regions with agricultural economies and rich biodiversity. A comprehensive analysis of starch-based packaging production, with a detailed understanding of each stage and the overall process, should contribute to the development of more sustainable and scalable solutions, particularly for the replacement of single-use packages, helping to protect vulnerable biodiverse regions from the growing impact of plastic waste.



Citation: Garavito, J.; Peña-Venegas,

Foods **2024**, *13*, 4096. <https://doi.org/10.3390/foods13244096>

<https://www.mdpi.com/journal/foods>

<https://www.mdpi.com/2304-8158/13/24/4096>

Piantare i semi del cambiamento negli stili alimentari: coltivare strategie di marca per promuovere alternative a base vegetale attraverso piattaforme online

Questo articolo approfondisce il panorama dell'industria alimentare a base vegetale, esplorando le strategie innovative di ingresso nel mercato e la loro interazione con il mercato alimentare in evoluzione e le mutevoli preferenze e stili di vita dei consumatori. All'interno del mercato europeo, la Germania ha la più alta spesa pro capite per alimenti a base vegetale, seconda solo ai Paesi Bassi. L'analisi del sentiment si basa sui cinque aspetti: prezzo, imballaggio, spedizione, marchio e qualità.



Article

Planting Seeds of Change in Foodstyles: Growing Brand Strategies to Foster Plant-Based Alternatives Through Online Platforms

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Abstract: This article delves into the landscape of the plant-based food industry, exploring innovative market entry strategies and their interplay with the evolving food market and shifting consumer preferences and lifestyles. Adopting a multidimensional approach, the study reflects diverse perspectives at play. Through a comparative analysis of strategic promotion and growth strategies employed by both innovative startups and established industry giants in the plant-based alternatives sector in Germany, the study aims to capture the challenges faced by the 'newer' wave of plant-based alternatives. This examination is particularly relevant for navigating the complexities of entering a competitive market. Striving to penetrate evolving consumer lifestyles, the study draws insightful comparisons with their "older" counterparts. In addition, through in-depth interviews with selected companies, the study investigates the entry methods of startups venturing into the German market, aiming to identify parallels and contrasts in market strategies with established brands. This provides valuable insights into innovation within the alternative food market. Furthermore, the study explores the process of brand "platformization" by scrutinizing the websites of the selected companies and analyzing customers' online reviews of their brand experience. This comprehensive analysis unveils distinctive patterns in communication strategies, brand positioning, and consumer engagement, offering insights into the ways plant-based innovation shapes new, caring lifestyles. The main findings include a strong correlation among dimensions related to food quality, use, and taste, indicating a holistic approach to food consumption facilitated by online platforms.



Citation: Bonetti, G.G.; van Hooven, C.; Onorati, M.G. Planting Seeds of

Gastronomy **2024**, *2*, 169–190. <https://doi.org/10.3390/gastronomy2040013>

<https://www.mdpi.com/journal/gastronomy>

<https://www.mdpi.com/2813-513X/2/4/13>

Sviluppo di un dispositivo di stampaggio a iniezione automatizzato a basso costo per applicazioni di riciclo sostenibile della plastica ed economia circolare

In risposta alla domanda critica di soluzioni innovative per affrontare l'inquinamento da plastica, questa ricerca presenta un sistema di stampaggio a iniezione di materie plastiche a basso costo e completamente automatizzato, progettato per convertire i rifiuti in prodotti sostenibili. Costruito interamente con materiali riutilizzati, l'apparecchio si concentra sulla lavorazione efficiente del polietilene ad alta densità (HDPE) senza componenti idraulici, migliorando così l'eco-compatibilità e l'accessibilità. Le valutazioni delle prestazioni hanno identificato una temperatura di stampaggio ottimale di 200 °C, che consente di ottenere prodotti coerenti con una deviazione di peso minima del 4,17%.



Article

Development of a Low-Cost Automated Injection Molding Device for Sustainable Plastic Recycling and Circular Economy Applications

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Abstract: In response to the critical demand for innovative solutions to tackle plastic pollution, this research presents a low-cost, fully automated plastic injection molding system designed to convert waste into sustainable products. Constructed entirely from repurposed materials, the apparatus focuses on processing high-density polyethylene (HDPE) efficiently without hydraulic components, thereby enhancing eco-friendliness and accessibility. Performance evaluations identified an optimal molding temperature of 200 °C, yielding consistent products with a minimal weight deviation of 4.17%. The key operational parameters included a motor speed of 525 RPM, a gear ratio of 1:30, and an inverter frequency of 105 Hz. Further tests showed that processing temperatures of 210 °C and 220 °C, with injection times of 15 to 35 s, yielded optimal surface finish and complete filling. The surface finish, assessed through image intensity variation, had a low coefficient of variation ($\leq 5\%$), while computer vision evaluation confirmed the full filling of all specimens in this range. A laser-based overflow detection system has minimized material waste, proving effective in small-scale, community recycling. This study underscores the potential of low-cost automated systems to advance the practices of circular economies and enhance localized plastic waste management. Future research will focus on automation, temperature precision, material adaptability, and emissions management.

Citation: Sinchai, A.; Boonyang, K.; Simmala, T. Development of a Low-Cost Automated Injection

Inventions **2024**, *9*, 124. <https://doi.org/10.3390/inventions9060124>

www.mdpi.com/journal/inventions

<https://www.mdpi.com/2411-5134/9/6/124>

Analisi della contaminazione da plastificanti durante la produzione di olio d'oliva

Questo studio ha monitorato la contaminazione di 32 plastificanti nell'olio d'oliva durante tutto il processo di produzione e stoccaggio. L'analisi è stata condotta mediante gascromatografia con spettrometria di massa tandem (GC-MS/MS), con limiti di rivelazione compresi tra 0,001 e 0,103 mg/kg. I risultati hanno rivelato che le concentrazioni di plastificanti aumentavano progressivamente in ogni fase del processo di produzione, sebbene anche le olive non trasformate contenessero contaminanti. Il diisononil ftalato (DINP) era il composto più diffuso, ma sono stati rilevati tutti gli ftalati regolamentati dall'Unione Europea per i materiali a contatto con gli alimenti, così come alcuni plastificanti non regolamentati.



Article

Analysis of Plasticizer Contamination Throughout Olive Oil Production

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Abstract: This study monitored the contamination of 32 plasticizers in olive oil throughout the production and storage process. Samples were collected at different stages of production from three olive oil production lines in distinct regions of Portugal and analyzed for 23 phthalates and 9 phthalates substitutes to identify contamination sources. The developed analytical method employed liquid-liquid extraction with hexane/methanol (1:4, v/v), followed by centrifugation, extract removal, and freezing as a clean-up step. Analysis was conducted using gas chromatography tandem mass spectrometry (GC-MS/MS), with detection limits ranging from 0.001 to 0.103 mg/kg. The results revealed that plasticizer concentrations progressively increased at each stage of the production process, although unprocessed olives also contained contaminants. Di-isononyl phthalate (DINP) was the most prevalent compound, but all phthalates regulated by the European Union for food contact materials were detected, as well as some unregulated plasticizers. In a few packaged olive oils, DINP concentrations exceeded the specific migration limits established by European regulations. Samples stored in glass and plastic bottles showed no significant differences in plasticizer concentrations after



Citation: Freitas, F.; Brinco, J.; Cabrita, M.J.; Gomes da Silva, M. Analysis of

Molecules 2024, 29, 6013. <https://doi.org/10.3390/molecules29246013>

<https://www.mdpi.com/journal/molecules>

<https://www.mdpi.com/1420-3049/29/24/6013>

In che modo ridurre l'uso della plastica di origine fossile può aiutare la sostenibilità complessiva dell'ostricoltura: il caso del Golfo di La Spezia

Per analizzare le potenziali strategie per ridurre l'impatto ambientale dell'allevamento di ostriche, sono stati presi in considerazione scenari alternativi in cui i materiali a base fossile sono stati sostituiti con materiali a base biologica. In particolare, questo studio ha esaminato la sostituzione dell'attuale imballaggio, costituito da una scatola di legno e da un film di polipropilene (PP), con una rete in PP completamente riciclabile. Inoltre, l'acido polilattico (PLA), i poliidrossialcanoati (PHA) e il polietilene tereftalato a base biologica (Bio-PET) sono stati proposti come alternative al polietilene vergine ad alta densità (HDPE) e al PP per boe, sacchi per ostriche e scatole.



Artide

How Reducing Fossil-Based Plastic Use Can Help the Overall Sustainability of Oyster Farming: The Case of the Gulf of La Spezia

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Abstract Oyster farming plays a crucial role in sustainable food production due to its high nutritional value and relatively low environmental impact. However, in a scenario of increasing production, it is necessary to consider the issue of plastic use as a limitation to be addressed. A life cycle assessment (LCA) was conducted on oyster farming in La Spezia (Italy) as a case study, utilizing 1 kg of packaged oysters as the functional unit. Fossil-based plastics and wooden packaging were identified as the primary environmental concerns. To analyze potential strategies for reducing the environmental impact of oyster farming, alternative scenarios were considered wherein fossil-based materials were replaced with bio-based materials. Specifically, this study examined the substitution of the current packaging, consisting of a wooden box and a polypropylene (PP) film, with a fully recyclable PP net. Additionally, polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and bio-based polyethylene terephthalate (Bio-PET) were proposed as alternatives to virgin high-density polyethylene (HDPE) and PP for buoys, oyster bags, and boxes. Among the scenarios analyzed, the sole effective strategy to reduce the impact of plastics on the process is to replace them with PHA. In the other cases, the high energy consumption of their non-



Resources 2025, 14, 10

<https://doi.org/10.3390/resources14010010>

<https://www.mdpi.com/2079-9276/14/1/10>

Valutazione di possibili contaminanti da materiali sostenibili destinati al contatto con gli alimenti

La transizione ecologica sta portando l'industria verso l'utilizzo di materiali di origine naturale, che spesso vengono proposti per i materiali a contatto con gli alimenti come soluzione sostenibile per ridurre l'uso della plastica. Sono percepiti come sicuri dai consumatori. Tuttavia, per valutare la sicurezza è necessario un controllo rigoroso sui potenziali contaminanti in grado di migrare verso alimenti e bevande. Pertanto, lo sviluppo di metodi analitici per il rilevamento e l'identificazione di sostanze potenzialmente nocive è fortemente incoraggiato e la combinazione di diverse tecniche può essere una soluzione per ottenere informazioni complementari. In questo lavoro, GC-MS, HPLC-MS, ATR-IR ed ESEM sono stati sfruttati con l'obiettivo di monitorare composti volatili e non volatili e di controllare la composizione e la morfologia della superficie.



Article

Evaluation of Possible Contaminants from Sustainable Materials Intended for Food Contact

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Abstract The ecological transition is leading industry towards the use of materials of natural origin, which are often proposed for food contact materials as a sustainable solution to reduce plastic use. They are perceived as safe by consumers; however, a strict control on potential contaminants able to migrate to food and beverages is necessary to assess safety. Thus, the development of analytical methods for the detection and the identification of potentially occurring harmful substances is strongly encouraged, and the combination of different techniques can be a solution to obtain complementary information. In this work, GC-MS, HPLC-MS, ATR-IR and ESEM have been exploited with the aim of monitoring both volatile and non-volatile compounds, and to control surface composition and morphology. Extraction with solvent and migration experiments with simulants were performed on 11 commercial samples, including plates, caps, and wooden coffee stirrers. Global and



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