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Editorial

Technological Advancements in Food Processing and Packaging

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The global challenge of providing sufficient, safe, and sustainable food to a growing population requires continuous food processing and packaging technology advancements. With the world's population projected to exceed 9 billion by 2050, addressing the increasing demand for food production and agricultural productivity is more critical than ever. To bridge this gap and ensure food security, exploring innovative approaches that enhance the efficiency and effectiveness of food processing and packaging is essential. These advancements not only play a crucial role in maintaining food safety and quality but also contribute to sustainability efforts by reducing food waste, optimizing resource utilisation, and preserving the nutritional value of food. By continually pushing the boundaries of technology and exploring novel techniques, we can meet the challenges of feeding a growing population while safeguarding the environment and ensuring the long-term availability of safe and nutritious food.

This Special Issue brings together a collection of research papers highlighting the latest developments and applications in food processing and packaging, aiming to ensure food safety, extend shelf life, and preserve nutritional value. The diverse range of topics covered in this issue demonstrates the multidisciplinary nature of this field and the need for innovative solutions to meet the future demands of the food industry. The issue consists of three sections, focusing on innovative packaging solutions for food quality and safety [1–3], enhancing food safety and quality [4–6], and mechanical innovations in food processing [7].

As Guest Editors of this Special Issue, we would like to thank the authors for their valuable contributions and the Editorial Staff of *Processes* for their professional support during the publication process. We believe that this compilation will prove instrumental in enhancing postharvest technology, a pivotal element of ensuring global food security.

1. Innovative Packaging Solutions for Food Quality and Safety

In today's rapidly evolving food industry, the quest for enhanced food quality and safety has spurred groundbreaking innovations in packaging technologies. The papers grouped under the heading "Innovative Packaging Solutions for Food Quality and Safety" delve into cutting-edge approaches that redefine how we think about food preservation. By harnessing the potential of novel materials, coatings, and packaging designs, these studies aim to extend the shelf life of food products and maintain their freshness, appearance, and nutritional content.

In a comprehensive review by Fadiji et al. [1], the authors presented an in-depth exploration of the emerging field of antimicrobial packaging and its crucial role in extending the shelf life of various food products. The paper delves into the ongoing challenges posed by the demand for minimally processed foods and changing eating habits, which necessitate innovative solutions to enhance food safety and quality. The authors emphasised that antimicrobial packaging is a dynamic and evolving technology, designed to combat the growth of harmful microorganisms and ensure the preservation of food products. Through a meticulous analysis of various antimicrobial substances used in packaging, the review highlighted the multifaceted approaches employed to suppress microbial activities and maintain product freshness.

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The review underscored the importance of antimicrobial packaging as an active and responsive solution that releases specific agents to inhibit microbial growth, effectively enhancing food safety during storage. The authors explored diverse types of antimicrobial systems and their applications, focusing on their effectiveness in different food categories, such as fresh and minimally processed fruit and vegetables, as well as meat and dairy products. The authors emphasised the potential of natural antimicrobial agents, which are gaining prominence for their efficacy and sustainability. The paper further discussed the selection of the most suitable antimicrobial packaging system, which hinges on factors such as product nature, desired shelf life, storage conditions, and regulatory considerations. The comprehensive insights provided by this review contribute to the evolving landscape of food packaging technologies, offering a deeper understanding of antimicrobial packaging's capabilities and limitations. By highlighting the significance of this field in ensuring food safety and extending shelf life, the authors advocate for further research and application of antimicrobial packaging solutions.

Kassem et al. [2] focussed on applying innovative packaging techniques to enhance the quality and shelf life of "Tommy Atkins" mangoes. The authors explored the effects of coating mango fruit with films containing nano-silica and chitosan, aiming to improve various parameters that indicate fruit quality. The coated mangoes were subjected to a storage regimen that simulated real-world conditions, transitioning from lower (13 ± 1 °C and 90–95% relative humidity) to higher (20 ± 2 °C and 70–75% relative humidity) temperatures. The coated mangoes were compared with uncoated control samples throughout the study. The results revealed significant improvements in various aspects of fruit quality for the coated mangoes. The coating treatments reduced weight loss and decay percentages compared to the uncoated control samples over the storage period. Additionally, the coated treatments exhibited delayed skin degreening, suppressed respiration rates, reduced endogenous ethylene production, and maintained firmness compared to untreated control fruit.

Despite a decrease in titratable acidity and vitamin C content during storage, the reduction was less pronounced in the coated fruit. Furthermore, the coated mangoes experienced controlled increments in total soluble solids and total sugars while retaining high levels of total phenolics and antioxidants. This combination of effects indicated an extended effective marketing period for the coated fruits, showcasing the potential of nano-silica/chitosan film coatings in preserving mango quality. The study established that the combination of 2% chitosan and 1% nano-silica dioxide successfully maintained the quality of "Tommy Atkins" mangoes during cold storage and marketing, highlighting a promising avenue for enhancing food quality through innovative packaging solutions.

Exploring cutting-edge packaging approaches, Kawhena et al. [3] explored the impact of coating pomegranate fruit with gum Arabic and starch-based films, along with using different polyliners, on postharvest quality attributes during cold storage. The study investigated weight loss, respiration rate, total soluble solids, and decay percentage of the coated and uncoated fruit packed with various polyliners. The results highlighted that combining gum Arabic–maize starch coating with polyliners effectively reduced weight loss and respiration rate and maintained fruit quality compared to uncoated fruit. This approach presented a potential biodegradable alternative to plastic polyliners for extending the shelf life of pomegranates. The study suggested that the synergistic activity of coatings and polyliners can significantly contribute to preserving postharvest fruit quality and promoting sustainability in packaging practices.

2. Enhancing Food Safety and Quality

The significance of maintaining food safety throughout handling and processing cannot be overstated. The collection of papers in this Special Issue provides insights into innovative approaches and technologies that play a pivotal role in mitigating microbial activity, minimising damage, improving postharvest handling, preventing spoilage, and ensuring the safety and quality of food products. Harizi et al. [4] investigated the impact

of various drying techniques and gamma irradiation on the antioxidant activities and phenolic content of dried skim camel and cow milk fractions. The study employed acid or enzymatic coagulation followed by either spray drying or freeze drying, coupled with different doses of gamma irradiation. Results revealed that the freeze-drying process led to higher total phenolic content than spray-dried fractions, with the β-casein fraction of camel milk exhibiting significant antioxidant activity. Moreover, gamma irradiation at specific doses effectively preserved the antioxidant properties of milk fractions, offering the potential for enhancing the preservation of powdered milk. The study highlighted the potential of freeze-dried milk fractions and acid whey from camel and cow milk as intriguing subjects for further exploration regarding antioxidant assays and other biological activities. Overall, the research highlighted the significance of drying techniques and irradiation in boosting the antioxidant properties of milk-based products.

Meléndez-Pérez et al. [5] evaluated the formation of frost on frozen pork meat packed with two different plastic films, namely Polyvinyl Chloride (PVC) and low-density polyethylene (LDPE). The study examined how frost forms on the meat's surface and within the packaging when subjected to freezing and subsequent storage conditions. The authors reported significant differences between PVC and LDPE films by analysing frost thickness, FTIR spectra, and thermal changes by Modulated Differential Scanning Calorimetry (MDSC). PVC-coated meat demonstrated lower frost thickness due to its unique polymer matrix, indicating improved stability at lower temperatures. FTIR and MDSC analyses further unveiled molecular-level alterations, highlighting the influence of packaging material on frost formation and meat preservation. This study broadens the understanding of frost dynamics within frozen food packaging and contributes to the potential development of improved packaging materials for maintaining product quality.

Pathare et al. [6] assessed the impact of mechanical damage, specifically bruising, on stored pomegranate fruit. The study employed a pendulum test technique to induce controlled bruising at different impact levels: 1.189 J and 2.298 J. Subsequently, the authors examined the effects of storage temperature and duration on bruise magnitude and fruit quality attributes. During the 28-day storage period, the results revealed that higher impact levels and warmer storage temperatures increase. The study establishes correlations between bruise parameters and quality attributes such as total soluble solids (TSS) and titratable acidity (TA%). The findings emphasised the importance of considering bruising and storage conditions in postharvest handling to maintain pomegranate fruit quality. This research enhances the knowledge of fruit susceptibility to mechanical damage and aids in developing strategies to mitigate quality degradation during the supply chain.

3. Mechanical Innovations in Food Processing

Mechanical innovations are pivotal in revolutionising how we handle, manipulate, and enhance food products. Moșneguțu et al. [7] thoroughly investigated the geometric aspects of a four-bar mechanism used in driving oscillating screens for separation systems. The study uncovered crucial relationships between positioning and resulting motion by analysing the impact of different positions of the actuation mechanism, particularly the connecting rod angle. Through mathematical calculations and analytical tools, the research revealed key parameters affecting the oscillating motion of the sieve, providing insights that can enhance the precision and efficiency of separation systems in food processing equipment design and optimisation.

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