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Review

Quercetin infused starch matrix as a sustainable approach to smart packaging: A comprehensive review

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ABSTRACT

Starch-quercetin films characterize an innovative approach in the development of functional packaging solutions with sustainable and biodegradable characteristics in materials used in food industry. The quercetin bioactive attributes induced in the starch polymers exhibit incredible antioxidant, antimicrobial as well and mechanical and barrier properties. The free radical-scavenging activity offered by quercetin protects the packaged food from oxidative rancidity, while its antimicrobial properties help control foodborne pathogens, thereby extending the shelf life of perishable products. Furthermore, the quercetin films offer superior UV protection and moisture barrier qualities making them suitable for a wide range of applications, including active, intelligent, and edible packaging. Recent advancements, such as blending with various biopolymers like chitosan or gelatin and incorporating nanoparticles, have further enhanced the functionality of the packaging films. However, certain challenges such as low solubility of quercetin, thermal instability and its high production costs remains a great barrier in its industrial application. Therefore, there is a great need to focus on greener processing methods, nanocomposite integration including cost-effective production strategies to overcome these limitations. This paper highlights the potential of starch-quercetin matrices as a sustainable alternative to plastic packaging, addressing global environmental concerns while ensuring food safety and quality.

1. Introduction

In the era of increased emphasis placed on food safety and quality, coupled with ensuring the same to the targeted consumer basket, there is a tremendous scope for the advanced packaging technologies. There is a continuous scope and complexity associated with the design, development and integration of various packaging formats to fulfil the evolving industrial responsibility. The conventional packaging role of containment and protection need to be expanded to suit the present market requirement of real time monitoring of the food status [1]. Taking into considerations, packaging industry has evolved with wide array of options aimed at substituting or replacing the petrochemically derived polymers. Active and Intelligent packaging which are increasingly used for preservation principle are the categories of smart packaging that aims at increasing the shelf life or assist in tracking quality information either by interacting with food or surrounding matrix [1]. While the former has more to interact with food matrix by the use of bioactives, and allied additives for increasing shelf life, the latter is more focussed on providing traceability for the food in transit. This has continued with the resultant of sensors [2], barcodes [3], indicators [4] and radio-frequency [5] based sensing for accuracy in detecting quality parameters. Increased application of these smarter packaging systems has been investigated on fruits [6], vegetables [7], meat [8], bakery product [9] avenues.

The biodegradable polymers can be either biomass derived (proteins, lipids, polysaccharides), or synthesized from monomers (lactic acid), or

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