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Innovative Approaches to Pectin Extraction: Synergistic Effects of Cold Plasma and Ultrasonication on Dragon Fruit Peel Powder

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Abstract

In recent years, there has been a significant increase in the cultivation and consumption of dragon fruit due to its distinct flavor and abundant nutritional and medicinal benefits [1]. The dragon fruit (Hylocereus spp.) peel has a high concentration of pectin, which, if properly processed and exploited, may significantly enhance the overall value of the dragon fruit[2]. Citrus and apple residue are the main sources of pectin on the market; however, they are quite limited in quantity. Hence, it is crucial to broaden the source of pectin production. Ultrasound and Cold plasma aided extraction efficiently extracts bioactive components in a shorter duration, at reduced temperatures, with lower energy consumption and solvent usage. These methods are superior method for preserving the functioning of bioactive chemicals compared to thermal extraction techniques.[3], [4]. Therefore, we were interested in investigating the impact of ultrasonication and cold plasma treatment several methods of pectin extraction utilizing dragon fruit peel and boiling water treatments on the pectin component, which is influenced by the plant source and extraction circumstances.

The objective of this study was to examine the impact of ultrasonication and cold plasma treatment on the chemical properties of pectin derived from dragon fruit peel. Additionally, the study aimed to compare the ability of dragon fruit peel pectin films to form a film and their characteristics with those of commercially available citrus pectin films. The findings revealed a substantial enhancement in the efficiency of extracting pectin, resulting in a yield increase of up to 35% when compared to peels that were not treated. The pectin that was obtained showed a greater level of esterification, which suggests that it has excellent gelling capabilities. In addition, the cold plasma treatment improved the quality of the pectin. Reactive oxygen and nitrogen species present in the cold plasma play essential role in extraction of bioactive compounds. Furthermore, the treatment not only enhanced the extraction of pectin but also resulted in the production of bioactive substances in the peel of the dragon fruit. Consequently, there was a significant augmentation in the level of antioxidant activity of the treated samples. The processed peels also demonstrated enhanced color stability and a heightened red hue, rendering them promising natural colorants for use in culinary applications.

The pectin yield varied between 6.0% and 35.0%, and there were significant differences in physicochemical parameters across the techniques used ($p < 0.05$). The FTIR study demonstrated that the extraction procedures did not modify the fundamental structural structure of the pectin. This study highlights the impact of ultrasonication and cold plasma-based extraction methods on dragon fruit peel pectin functionalities and their structure–function relationship, providing valuable insights into predicting dragon fruit peel's potential as a food-grade ingredient in various products. Overall, the results indicate that cold plasma treatment has great potential as an environmentally friendly approach for enhancing the value of dragon fruit peel. This technique provides sustainable solutions for the food sector by transforming agricultural waste into valuable functional ingredients, such as pectin, natural colorants, and taste enhancers. The findings suggest that the application of cold plasma treatment shows promise as an eco-friendly method for using dragon fruit peel, offering sustainable solutions for the food industry by converting waste into valuable functional constituents.

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