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"ANALYSIS OF NANOPARTICLE SYNTHESIS BASED ON FLAVONOID EXTRACT DERIVED FROM POMEGRANATE PEEL (PUNICA GRANATUM)."

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Abstract: In this article, the scientific data obtained from the research results will contribute to the development of biologically active nanoparticles. Because nanoparticles synthesized from pomegranate peel flavonoids possess antibacterial, antifungal, and antioxidant properties, they can be applied in pharmaceuticals, medicine, the food industry, and agriculture.

Keywords: Flavonoid, extract, technology, nanoparticles, research, ecology, chemical

In recent decades, nanotechnology has been recognized as one of the most promising areas in the advancement of science and technology. Nanoscale materials possess unique physicochemical properties, exhibiting significantly higher reactivity, surface area, and biological activity compared to conventional materials. Consequently, nanoparticles are widely applied across numerous fields, including medicine, pharmaceuticals, biotechnology, the food industry, ecology, and agriculture. Various methods exist for synthesizing nanoparticles, with physical, chemical, and biological approaches being the most common. Traditional chemical methods often require toxic reagents and high energy consumption, which can lead to environmental issues. Therefore, in recent years, there has been growing interest in "green synthesis" methods, which are environmentally safe, cost-effective, and rich in biologically active components.

Under modern living conditions, as many researchers have noted, the value of biologically active compounds in food products is of particular importance for human activity. Biologically active substances include enzymes, vitamins, and hormones. These are vital and essential compounds, each playing an indispensable and crucial role in the vital functions of the human body. These natural antioxidants inhibit free radical oxidation processes in the human body, slowing down the aging process and the development of many diseases. Many plant enzymes and vitamins (such as ascorbic acid, carotenoids, P-active substances, etc.) possess antioxidant properties that protect the body from oxygen free radicals. Pectins derived from fruits and berries are capable of neutralizing and removing heavy metals and radionuclides from the body, as well as reducing cholesterol levels.

In Latin, the word for pomegranate, "granatus," means "family." The fruit contains approximately 700 seeds. More than ten species of this fruit are found in nature, distinguished by their color and taste. The growing season for the pomegranate is around 180–210 days. It blossoms in early summer, and the fruits ripen in September and October. The tree begins to bear fruit 3–4 years after planting. Depending on the variety, weather, and growing conditions, the average yield of pomegranate varieties ranges between 150 and 200 centners. Over 500 varieties of pomegranates are known, about 60 of which are widely used in commercial production across various countries around the world. The pomegranate (Punica granatum L.) is an ancient and widespread fruit native to Iran, Afghanistan, and other regions of Central Asia. Pomegranate plants are known for their drought tolerance—meaning they can maintain normal plant functions even at low tissue water potentials—as well as their ability to thrive in diverse climatic conditions. Beyond its nutritional value, numerous studies have established the medicinal properties of the pomegranate, including its antibacterial, anti-inflammatory, and antiviral effects, as well as its benefits for cardiovascular health and obesity. Long-term natural hybridization, gene mutation, and the use of various selection and propagation methods (such as crossbreeding, ramets, grafting, etc.) have resulted in an extensive collection of pomegranate

varieties. The identification of these varieties is based on the external and internal characteristics of the fruit. Martinez-Nicolas et al. found that the size of the pomegranate fruit and seed correlates relatively strongly with the pH value of the juice. However, differences in leaf and flower characteristics among varieties are insignificant, which indicates a certain correlation between the phenotype and the physiological state of the pomegranate. The pomegranate (Punica granatum L.) is a versatile plant of great scientific importance. Its unique botanical features, including drought tolerance, reproductive biology, and nutritional profile, have made it a subject of interest for botanists, agricultural scientists, and medical researchers. The potential applications of the pomegranate in agriculture, horticulture, and medicine are currently being studied, demonstrating its multifaceted significance across various fields. Its unique botanical features, including drought resistance, reproductive biology, and nutritional composition, have made it a subject of interest for botanists, agricultural scientists, and medical researchers.

However, few scientists have focused on comprehensive research on pomegranate seeds. In China, pomegranate seeds are discarded as waste, which pollutes the environment and leads to a waste of resources. Some scientists are developing new ways to utilize pomegranate seeds; for instance, adding pomegranate seed powder to bread significantly improves its antioxidant activity. Lucci et al. proposed using an ethanol extract of pomegranate seeds as a food additive and functional food ingredient, leveraging its hormone-independent antioxidant and antiproliferative effects against human prostate and breast cancer cells. These studies demonstrate the potential of using these fruit byproducts as natural antioxidants. Regarding soil conservation, pomegranate trees have a deep root system that helps prevent soil erosion and improve soil structure. Their roots can penetrate deep into the soil, anchoring it and preventing it from being eroded by wind or water. The pomegranate has a rich history, and its scientific significance extends beyond mere consumption; its agricultural benefits, nutritional value, and potential medicinal properties make it a valuable crop with significant potential across various fields. As research continues to explore the capabilities of the pomegranate, we will discover even more benefits of this versatile fruit.

In conclusion, it should be noted that the role of biologically active substances derived from plant sources in the synthesis of nanoparticles is increasingly becoming the subject of scientific study. Flavonoids, in particular, possess strong antioxidant properties and have the ability to reduce metal ions and stabilize the resulting nanoparticles. Therefore, flavonoid-rich plant extracts are considered a promising source for nanoparticle synthesis.

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