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SYNTHESIS OF FUNCTIONALIZED SELENIUM NANOPARTICLES WITH THE PARTICIPATION OF FLAVONOIDS

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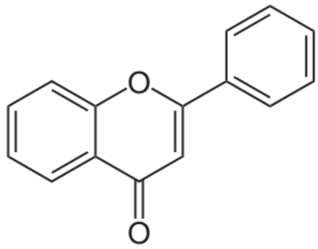
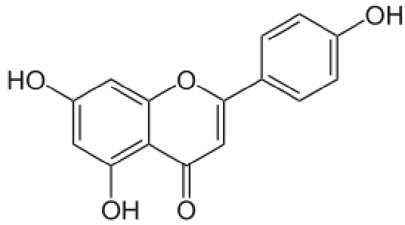
Introduction. Nanotechnologies play a key role in all fields of science, and the synthesis and modification of the surface of nanoparticles are crucial in this area. Nanoparticles synthesized using plant extracts or phytocomponents are of great importance in the development of various therapeutic and diagnostic tools [20].

Biogenic, "green" synthesis of nanoparticles of metals, metal oxides and metalloids with the participation of plants and microorganisms, combines biological principles with biochemical approaches to obtain nanosized functional particles with the necessary properties [5; 28; 30]. Ecological purity of production of nanostructures, the use of which is growing rapidly, is an urgent problem today [36]. Advantages of further synthesis by biological means, ie using microorganisms such as yeast, fungi, bacteria and parts of plants such as stems, roots, leaves, bark, flowers, etc., include non-toxicity, easy reproducibility and cost-effectiveness [4; 33; 26; 27].

Various strategies and biomodifiers, in particular with the participation of flavonoids, are used for surface modifications / functionalization of these nanomaterials. Flavonoids are one of the most common classes of compounds found in fruits and vegetables. The chemical structure is a group of aromatic substances with a general formula C_6-C_3-C_6. Their molecules are made up of two phenyl residues connected by a propane link that can be enclosed in an oxygen-containing heterocycle. They are divided into true, isoflavonoids, neoflavonoids. Flavonoids differ in class, and although structurally unique, they have a common basic structure formed by three rings known as the flavan nucleus. The position of the hydroxyl group (-OH) in one of the rings determines the mechanisms of action of flavonoids and exhibits complex multifunctional activity. Flavonoids are widely used as antioxidants, analgesics, and have anti-inflammatory effects along with safe preclinical and clinical studies [11]. Flavonoids are divided into classes: flavones (flavone, apigenin and luteolin), flavonols (quercetin, kaempferol, myricetin and fisetin) and flavanones (flavanone, hesperetin and naringenin).


flavone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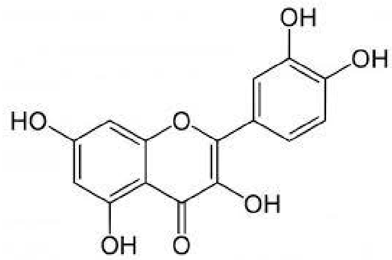
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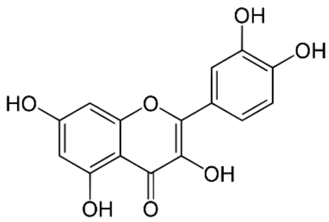
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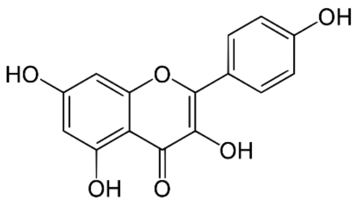
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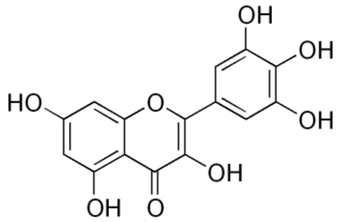
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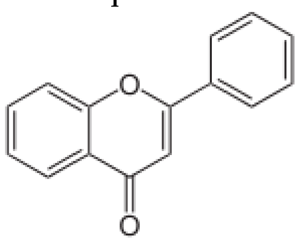
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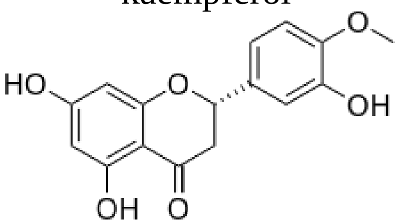
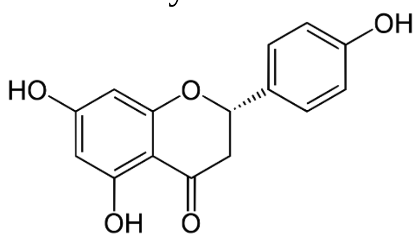

hesperetin


naringenin

Quercetin Кверцетин (3,3',4',5,7-pentahydroxyflavone) is a flavonol found in various types of fruits, vegetables and plants, including: berries, apples, tomatoes, cocoa, onions and herbs [12; 19]. Це антиоксидантний флавоноїд, який проявляє протизапальну активність за рахунок інгібування прозапальних цитокінів [13], oxidative stress [7], NLRP3 inflammatory activity in macrophages [10], p65 NF-κB activation [14; 18], MAP kinase signaling in macrophages [18], activation of p50 NF-κB in primary human keratinocytes [31] and production of TNF-α, IL-1β and IL-6 in LPS-stimulated cells [8]. In addition to inhibiting the above pro-inflammatory signalling pathways, part of this effect is due to activation of the Nrf2/HO-1 pathway [7; 14]. However, poor solubility in water, intensive metabolism in the first pass limits the clinical use of quercetin [20]. Quercetin-conjugated selenium nanoparticles have been shown to inhibit the aggregation of amyloid-β structures, which are a hallmark of Alzheimer's disease and exhibit antioxidant properties. Such nanocomposite carriers significantly increase the solubility in water and bioavailability of quercetin (QueSeNP) [23].

Biological synthesis is one of the most environmentally friendly methods of synthesis of nanostructures. Moreover, if the synthesis is carried out with the help of waste, such as vegetable waste, the synthesis process not only becomes green, but also environmentally friendly. One of such vegetable wastes is onion, ie waste of onion peel. However, the processing of onions at the household or industrial level produces a large amount of waste, including unfit for human consumption: the upper and lower parts, the outer skins and skins and the two outer layers [9]. It is reported that among all producers, only European countries can generate almost 0.6 million tons of onion waste annually [15]. In addition, these wastes can have a detrimental effect on the environment if they are not disposed of properly, as they are not suitable for feed preparation and cannot be used as fertilizer [2]. Therefore, onion waste remains underused even after establishing the fact that it is a rich source of biologically active compounds such as phenols, flavonoids and flavanols. Thus, increasing the value of onion waste and its extracts in biotechnology, biomedicine, pharmaceuticals and the agro-industrial sector can be the best solution to reduce environmental damage and provide a cost-effective alternative to the production of medicinal supplements or medicines based on rare herbs [16].

Onion peels are considered to be wastes that contain 20 times more quercetin and quercetin glycosides than the edible part [17]. Onions have been shown to have numerous phytochemicals, flavonoids and enzymes that promote nanoparticle synthesis [16]. Despite differences in varieties or extraction methods, the main phenolic compound identified in onion peel was quercetin. Identified compounds included quercetin 4'-O-glucoside and quercetin, as well as other quercetin glycosides, cyanidin 3-O-glucoside, and a number of quercetin degradation and oxidation products [16].

Quercetin has a protective effect on cancer and cardiovascular disease, chronic inflammation, oxidative stress and neurodegenerative pathologies due to its anti-radical and anti-inflammatory properties, however, its poor bioavailability inhibits the potential beneficial effects of this flavonoid. In this sense, different types of nanocarriers have been developed to improve the solubility of quercetin, as well as to develop tissue-specific delivery systems. These studies improve the bioavailability of quercetin and increase its concentration in the right places. Thus, quercetin can be a promising compound if nanotechnology is used as a tool to increase its therapeutic efficacy [22].

Instead of using commercially available quercetin as a capping agent for the synthesis of gold nanoparticles, researchers [24] used onion peel as a cheap source of quercetin, which can act as a strong reducing agent and capping agent, and established its synergistic antioxidant and anti-inflammatory effects. In studies, giving priority to the rational use of natural resources, the whole crude extract of onion peel is purified to four fractions, namely: ethyl acetate, butanol, methanol and water [21].

In contrast to the use of organic extractants, in studies [1] used an aqueous extract of onion peel in the case of obtaining the method of green synthesis of silver nanoparticles.

Among the various nanostructures, selenium nanoparticles are characterized by unique properties such as high catalytic and biological activity [29]. Selenium nanoparticles obtained by green chemistry affect the redox-sensitive signaling system Keap1/Nrf2/ARE, the main purpose of which is to maintain internal homeostasis under various stressors by activating transcription and synthesis of a number of antioxidant and detoxifying enzymes [3; 6]. Quercetin has been shown to counteract neuroinflammation by activating Nrf2/HO-1 and inhibiting NF-κB signalling [25]. Thus, the functionalization of selenium nanoparticles with quercetin may contribute to the effect of the nanocomposite on the transcription factors Nrf2 and NF-kB, key pathways that regulate the fine balance of cell redox status and response to stress and inflammation. It is established that selenium nanoparticles can be effectively used in animal husbandry, poultry and other branches of agricultural production [32; 34; 35].

Our research is aimed at the synthesis of selenium nanobioconjugates with quercetin using an aqueous extract of onion peel, which is a waste of agro-industrial production.

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