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Biological applications of propolis nanoparticles.

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ABSTRACT

Propolis is a honeybee substance that has a long history of usage in conventional medicine. Propolis contains many phytoconstituents and active biomolecules, including phenolic acids, enzymes and flavonoids compounds. It promotes health and helps prevent diseases. Propolis has been extensively studied for its bioactive potential, including free radical scavenger, inflammation suppressor, antimicrobial, antiviral compounds, fungicide, antineoplastic, and tumor inhibiting properties. Propolis contains beneficial characteristics and can be used to create functional foods. Nano-propolis promotes veterinary medicine by adjusting the size of propolis by various approaches. Free form propolis has limited benefits because to its low bioavailability, solubility, absorption, and lack of tailored control. Nano-propolis is produced by a number of nanoencapsulation techniques. Nano-propolis, due to its tiny size, is better absorbed by the body. However, some bee products may cause allergies, so use with caution. This review summarizes latest findings on the efficacy of propolis nanoparticles, including its components and physiologically active chemicals, in treating multiple medical conditions.

1. INTRODUCTION

Botanical remedies with a long history of safe and successful therapeutic use in treating sickness in humans, some dating back thousands of years, could possibly be used as a fundamental or supplementary therapy that is commonly found and reasonably priced [1]. Propolis, a beehive product, has been found to have antibacterial, antioxidant, anti-inflammatory, and cell growth inhibitory activities. It has been utilized to heal diseases in cultures through history, including the ancient Egyptians, Romans, and Greeks, as well as ancient China and South and Central America, where bee farming is a vital part of daily life [2-3].

Bees collect resin and wax from plant components, including flowers, leaf blossoms, discharge, gums, and mucilage, and enrich them with their β-glucosidase saliva [4-7]. Propolis serves as a natural sealant for bees helping to repair hive damage and gaps, guard against outside invaders, control temperature and humidity, and create a sanitized hive environment [8].

Propolis contains around 500 components, including a broad spectrum of bioactive compounds as flavonoids, phenolic compounds, polyphenols, terpenes, coumarins, steroids, amino acids, and aromatic acids [9]. Furthermore, propolis contains a variety of vitamins and minerals as (vitamin A, B complexes, C, and E), and aluminum, salt, potassium, calcium, and other trace minerals [10,11], each playing a crucial part in biological activity [12]. Because bees collect the raw materials of propolis from various portions of plants, pigments and compounds produced by a variety of plants are found in propolis, and the chemical constituents change according to its territory, botanical sources (plant origins), seasonal changes, and bee strains [1].

a. Chemical Constituents

Propolis normally incorporates 50% fat, 30% hive wax, 10% essential oils, 5% pollen, and 5% chemical free ingredients. Stingless bee propolis has a significantly higher lipid content than European honeybee hives (8-16%), making it more resistant to water [14]. Bees acquire lipids from plant resins [15].

Organic components include carboxylic acids (20%), terpenoids (15%), steroids (12%), hydrocarbons (10%), sugars (6%), alkaloids (6%), flavonoids (4%), phenols (3%), vitamins (2%), amino acids (2%), ketones (2%), proteins (1%), and miscellaneous chemicals (14%) [16]. Biologically active compounds include flavonoids, polyphenols, carboxylic acids, quercetins, fatty acids, cinnamic acid, esters, and terpenoids like pinocembrin, galantine, caffeic acid, CAPE, saponin, phorbol, naringenin, gallic acid, naringin, benzoic acids, amino acids, apigenin, coumaric acid, steroids, vitamins, reducing sugar, and essential oils [13].

Flavonoid compounds and phenolic substances are key types of plant secondary metabolic products. Quercetin and chrysin are common flavonoids detected in propolis from various bee species. Plant resin contains flavonoids, which exhibit anticancer, antibacterial, and anti-inflammatory properties [17]. Flavonoids are classified into numerous types: flavanone, flavanol, isoflavone, flavanol, flavanonol, flavan-3-ol, and chalcone as in Figure 1 [18].

Nanotechnology is the science of synthesizing particles ranging in size from 1 to 100 nm. Nanoparticles were synthesized using physical, bottom-up, and top-down chemical approaches. However, these techniques have high expenses, causes environmental damage, and releases harmful agents. Biological green synthesis has gained popularity in recent years due to its ease, cost-effectiveness, and environmental friendliness [19]. Green synthesis of nanoparticles (NPs) is a cost-effective and ecologically friendly method that utilizes non-toxic solvents such as water. Nanoparticles (NPs) have antibacterial, antioxidant, and anticancer properties, making them effective for medication delivery Systems [20-22].

b. Nano propolis

Nano-propolis, consisting of particles ranging from 1 to 100 nm in diameter, aims to improve efficiency without modifying its properties. Nano-propolis can enhance effectiveness in fields such as medicine, physics, and biology [23]. Nano propolis enhances the ability to absorb materials, making it more soluble than propolis. Propolis nanoparticles can penetrate bacteria's outer layer, allowing antibiotic chemicals to target plant cell walls more effectively. Nano-propolis can be obtained using microencapsulation procedures [24]. Micro- and nano-propolis can be employed as antibacterial agents in food and healthcare goods, among other applications [23].

c. Synthesis of propolis nanoparticle

Preparation methods include spray-drying, microemulsion, high pressure homogenization, high-speed stirring, ultrasonication, emulsification-evaporation, and nanoprecipitation [23]. Microencapsulation method using casein micelle. The process of encapsulation involves trapping a material or combination of coated components within a system. The coating material is referred to as the shell, wall material, carrier, or encapsulant, and the coated material is called the active or core material. Therefore, a high-pressure ball mill homogenizer would be used to create nanoparticles of casein micelle-coated nano propolis [23].

d. Applications of propolis

i. Antioxidant activity

Products with high antioxidant capacity can help prevent diseases like cancer, cardiovascular disease, and diabetes [26]. Free radicals can cause oxidative damage to macromolecules such as proteins, nucleic acids, carbohydrates, and lipids, potentially leading to cell death. Propolis is rich in flavonoids and phenolic compounds, has been shown to have higher antioxidant activity than vitamin C and E [27]. Antioxidants can decrease enzyme activity, preventing the generation of reactive oxygen species. Caffeic acid phenyl ester (CAPE) contributes to the antioxidant effects of propolis. Propolis's antioxidant activity contributes to its anti-cancer benefits [28].

ii. Anti-inflammatory activity

Inflammation is a natural response to environmental stressors and accidental harm. Caffeic acid phenyl ester (CAPE) inhibited the production of pro-inflammatory cytokines, monocyte chemo attractant protein 1 (MCP-1), and tumor necrosis factor- α (TNF-α) in lipopolysaccharide LPS-stimulated RAW264.7 macrophages. propolis' anti-inflammatory characteristic originates from its flavonoid content, which inhibits inflammation caused by various substances [29].

iii. Hepatoprotective activity

Propolis possesses hepatic protecting characteristics. It enhances glutathione levels and reduces lipid degradation and glutathione depletion. Propolis increases redox protection and protects the liver from mercury toxicity. Studies have found that propolis extract can protect against CCL4-induced hepatorenal oxidative stress and damage. Propolis lowered the number of Kupffer cells, indicating its hepatoprotective effects [30].

The alcoholic extract of propolis has liver protective properties, reducing genetic damage in hepatocytes in cell culture, exhibiting anti-neoplastic potency in people primary liver cancer cell line, having no negative impact on normal cells, and decreasing liver enzymes and cirrhosis severity caused by thioacetamide [31]. Micellar propolis was shown to prevent rats from acute liver damage caused by CCl4 in vivo. PEO26-PPO40-PEO26 micelles may be an effective oral delivery method for propolis to protect liver cells from oxidative stress injury [32].

iv. Anti-diabetic properties

Propolis has antioxidant and hypoglycemic properties [33]. Previous research found that ethanolic and water extracts of propolis were effective for diabetic rats [34]. Propolis has been demonstrated in order to preclude oxidative damage in diabetic rats' tissues induced via alloxan and streptozotocin. Propolis protects against nephropathy. Propolis products have been demonstrated to minimize diabetic liver and kidney damage, possibly as a result of its antioxidant characteristics and detoxifying mechanism, which reduces free radical damage to cells. Propolis' capacity to protect mice modeling diabetes from reactive oxygen species-triggered injury implies it may have a similar defensive effect in human beings [35]. Egyptian propolis (EEP) coupled with chitosan polyacrylic (CS-PAA) nanoparticles may effectively lower blood sugar levels in rats' model of diabetes [36]. Propolis nanoparticles have been shown to reduce blood sugar levels as regenerate damaged cells in streptozotocin-induced diabetic rats, making them a promising therapy option. Propolis treatment in diabetic rats significantly reduced fasting blood sugar concentrations [37]. Propolis has been shown to reduce blood sugar levels in rats with alloxan-induced diabetes compared to a control group [38]. propolis may be a dietary supplement with potential therapeutic benefits for blood glucose control, preventative efficacy against diabetic hepatopathy, and little acute noxiousness [39].

v. Anticarcinogenic

Propolis has been shown to inhibit matrix metalloproteinases, prevent angiogenesis, prevent metastasis, halt the cell cycle, and induce apoptosis in recent studies [40-41]. Propolis has been shown in experiments on rats and people to be safe and without any negative effects. New techniques to maximize propolis' potential are urgently needed. Several studies have detailed strategies for encapsulating propolis extract in nanosized form [42].

vi. Healing process

Wound regeneration in the tissue is a complicated procedure that occurs as the skin's components regenerate after being injured. concisely, the tissue undergoes four phases: bleeding control, inflammation also cell growth and repair. Various clinical experiments have been undertaken with propolis in order to assess its impact on wound healing in organisms. Propolis has physical features that make it useful for wound closure [43].

A 2015 study investigated the function of propolis in cutaneous wound healing in adult dogs. Inflammatory cells, fibroblasts, keratinocytes, and endothelial cells all contribute to cutaneous wound healing. Bee glue paste was found to enhance the cutaneous tissue repair method in dogs in a time-sensitive manner. Propolis is presumed to have immunomodulatory, bactericidal, antioxidant, analgesic, plus anti-inflammatory properties, which speed up wound healing [44]. In a 2005 study in Turkey comparing propolis and silver sulfadiazine in the treatment of burns in Wester Albino rats, topical use of propolis was found to be efficient in limiting infection and producing clean granulation tissue. Another clinical trial in rats with three treatment groups (propolis, (SSD), and hydrating cream as a control) revealed that the propolis group was less inflamed than SSD. A combination of propolis cream treatment and wound healing demonstrated considerable improvement [43].

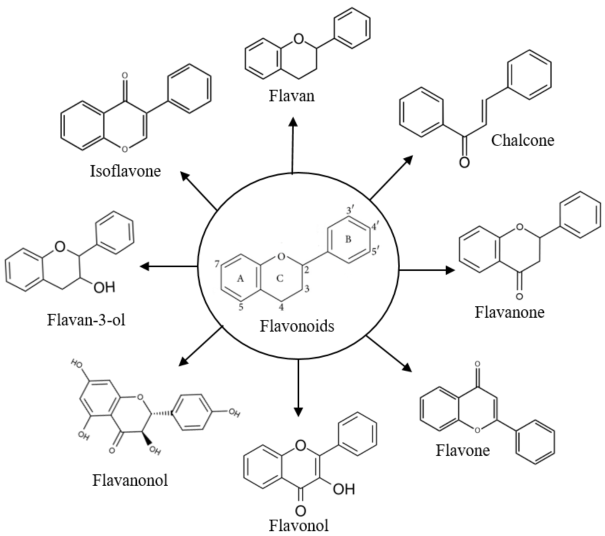

Fig. 1. Chemical structure of flavonoids [18]

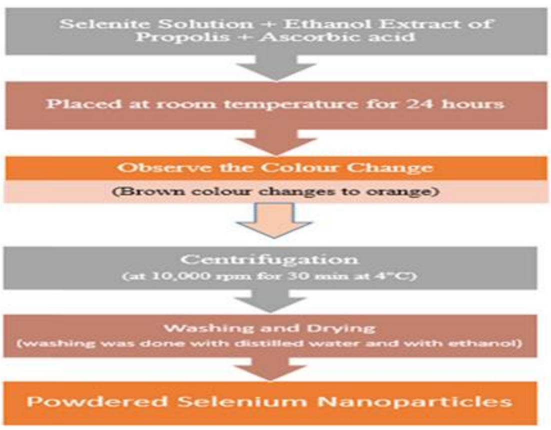

Fig. 2. Schematic representation for the synthesis of selenium nanoparticles from ethanolic extract of propolis. [23].

2. CONCLUSIONS

Nanotechnology offers a wide range of applications in human and animal health because to its rapid development and excellent bioavailability. Targeting. These benefits significantly improve cattle productivity, reduce economic losses, and promote healthier animal production. Nano-propolis outperformed traditional propolis in terms of effectiveness. Propolis's flavonoids contribute to its efficacy, making the proposed formulation suitable for use as a bioactive pharmaceutical. The carrier may improve the drug's effects. Future studies should investigate the impact of Nano propolis on drug interactions across disorders.

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