

Different applications of pistachio skin

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Information	Abstract
Article Type: Short Communication	<p>Iran is one of the largest producers of pistachios in the world. Therefore, in most parts of the country, pistachio skin is abundantly found. By investigating in this field, one can find suitable usages for this seemingly worthless skin. Pistachio skin, with its substances and compounds, has antioxidant and anti-inflammatory properties, so that some of these compounds have a higher concentration in pistachio skin compared to its nut itself. Pistachio skin has the ability to prevent the growth of fungi and bacteria as well. In addition to food and therapeutic usages, pistachio skin can be used in the production of fertilizers, activated carbon/various adsorbents to remove contaminants and some other applications. Given the amount of pistachio skin produced in Iran, planning and principled commercial measures for an optimal use seems to be necessary.</p>
Article History: Received: 21.07.2021 Accepted: 28.08.2021	
Doi: 10.22123/PHJ.2021.296212.1106	
Keywords: pistachio skin waste applications	
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► Please cite this article as follows:

Peirovi-Minaee R. Different applications of pistachio skin. Pistachio and Health Journal. 2021; 4 (3): 1-6.

1. Introduction

Pistachio tree is a small tree with a geographical area ranging from Asia to the eastern Mediterranean, and its major producers include Iran, USA, Turkey and Syria[1-3]. Pistachio is composed of different components such as pistachio kernel, pistachio skin and fresh pistachio skin. Raw pistachio by-products that are produced during pistachio processing in pistachio orchards include soft pistachio outer skin, spikes, leaves and a small amount of pistachio kernels and wood husks. Pistachio green skin is the main (more than 60%) by-product of pistachio and given its rapid decay, environmental pollution and health problems, it should be disposed of in a proper, hygienic and economic way[4]. Iran is one of the largest producers of pistachios in the world. Therefore, the hard skin that surrounds pistachio kernels is abundant in most parts of the country. In Iran, up to 400,000 tons of pistachio skin is produced annually[5]. By investigating various studies, it can be seen that this seemingly worthless skin can be used properly. In this study, it has been attempted to find various applications of pistachio skin (hard and soft) by reviewing texts and studies found by searching with the keywords pistachio hull waste, pistachio skin, pistachio shell, pistachio waste from different databases including Scientific Information Database (SID), Google Scholar, and Science Direct.

Pistachio skin compounds

Fresh pistachio skin is separated from pistachio fruit during processing and has been discarded as pistachio waste for many years and is a cheap source of phenolic compounds. Pistachio and its skin are rich sources of phenolic, antioxidant and anti-inflammatory compounds such as Gallotannins, Myricetin,

Gallic acid and Quercetin and are among the top 50 rich sources of phenolic compounds; these compounds are more found in pistachio skin than pistachio kernel[2, 6].

Applications in different studies

1. Oral/therapeutic

Different parts of pistachio plant including leaves, seeds and fruits have been reported to have anti-inflammatory, antimicrobial and anti-cancer properties). The results of various studies have indicated some biochemical properties of pistachio skin. These studies have indicated that pistachio skin can be used successfully in food and pharmaceutical industries[5, 7]. Studies show that the tendency to investigate the therapeutic properties of pistachio skin is higher than other applications, and research on various therapeutic effects is ongoing. For example, the antibacterial effect of hydroalcoholic (methanolic) extract prepared from fresh pistachio skin on gram-positive bacteria isolated from clinical samples showed that this extract is completely effective on the mentioned bacteria; it is recommended that these plant compounds be more frequently used to accelerate the healing of superficial bacterial infections of skin, especially in burns and food poisoning caused by *Bacillus cereus* as a natural food preservative. Compared to other bacteria, this extract has the most significant effect on *Streptococcus pyogenes*. Moreover, in comparison to amikacin antibiotics, clindamycin, and cefixime, it has the greatest effect. Given the non-growth halo diameter, susceptibility has the greatest effect on *Streptococcus pyogenes*, *Staphylococcus aureus* and *Bacillus cereus*, respectively[8]. Moreover, the results of the study on the effect of fresh pistachio skin extract in preventing the growth

of dermatophyte and saprophytic fungi in vitro have showed that pistachio skin extract has different antifungal effects on Trichophyton Mentagrophytes, Microsporum canis, Epidermophyton floccosum (dermatophytes), Aspergillus niger, and Candida albicans (saprophytes)[9]. The results of investigating the toxicity effect of hydroalcoholic extract of fresh pistachio skin and its liposomal form on liver cancer cell rank (HepG2) have also indicated that hydroalcoholic extract of pistachio skin reduces the viability of HepG2 cells and by increasing the time and concentration, cell viability rate decreases. The results of liposomal form of the extract also indicated that liposomal extract resulted in the reduced viability of HepG2 cells[2].

Tomaino et al have investigated the antioxidant activity and phenolic characteristics of pistachio kernels and skin (Pistacia vera L., Bronte cultivar). The results of their study showed that the content of total phenolic compounds in pistachio skin is significantly higher than that of the kernel. Measured by HPLC, Gallic acid, Catechin, Eriodictyol 7-O-glucoside, Naringenin 7-O-neohesperidoside, quercetin-3-O-rutinoside and Eriodictyol were found in both pistachio kernels and skin. Genistein-7-O-glucoside, Genistein, Daidzin, and Apigenin seem to be present only in pistachio kernels, while epicatechin, quercetin, Naringenin, Luteolin, Kaempferol, cyanidin-3-O-galactoside, and cyanidin-3-O-Glucosides are present only in pistachio skin. The antioxidant activity of pistachio seeds and skin was determined using four different methods (DPPH method, Folin-Ciocalteu colorimetric method, TEAC method, and SOD mimetic method). Accordingly, pistachio skin showed better activity than the kernel in all experiments. The excellent antioxidant activity of pistachio skin

can be owing to the high levels of phenolic antioxidant compounds. The presence of pistachios in the diet can be useful to protect human health against cancer, inflammatory diseases, cardiovascular damage and in general pathological conditions caused by excessive production of free radicals. Moreover, pistachio skin can be used successfully in food, cosmetics and pharmaceutical industries[10].

2. Fertilizer preparation

Fresh pistachio skin is one of the by-products of pistachio processing, which is classified as agricultural waste, infecting pistachio orchards and pistachio crop with Aspergillus fungus. Discharge of these substances into the environment causes the release of annoying odors and the growth and reproduction of flies. In addition, most farmers dispose of pistachio shells in pistachio orchards; due to the presence of unstable organic matter, it causes damage to the roots and thus stops plant growth. One of the important methods in recycling organic matter is the production of organic fertilizer (compost production). Yazdani et al have investigated the amount of heavy metals in the compost produced from pistachio skin and animal waste[4]. Malekoutian et al have also investigated the possibility of producing compost from a mixture of sewage sludge with pistachio husk waste. The results showed that the characteristics of the produced compost in terms of physicochemical properties are in the standard range of first and second class compost in Iran; it is thus recommended for agricultural use[11].

3. Preparation of adsorbent/nanoparticles

for removal and extraction of contaminants

The results of a study conducted by Khodadadi et al indicated that fresh pistachio

skin charcoal can be an efficient method with a relatively high efficiency for removing fluoride from aqueous environments[12]. Rohani et al have investigated the removal of lead from aqueous solutions using new adsorbents prepared from modified pistachio skin. In their study, adsorbents were prepared from freshly modified pistachio skins in acidic and alkaline conditions. According to the results, alkaline modified pistachio skins had more ability to remove lead from aqueous solutions, and they could be thus used as a cheap adsorbent to remove lead from aqueous solutions[13].

The researchers have also synthesized silver nanoparticles by fresh pistachio skin extract and use it to extract the solid phase Bi (III) and measure it by electrothermal atomic absorption spectroscopy. In this study, pistachio skin extract was used as a green reducing agent to produce Ag-NP from silver ion solution. This method was successfully used to determine a very small level of Bi (III) in water and food samples, human serum and hair[14].

4. Other applications

Fresh pistachio skin may be used as a food source for ruminants. However, given the toxicity of tannin content and the possibility of interaction with biomolecules, using these products by ruminants has been limited[5]. Fazayeli et al have investigated the use of different levels of pistachio shell in the diets of fattening lambs. The comparison of means with Duncan's multiple range test showed that consumption of dried pistachio shell up to 20% in the diet has not caused a significant difference ($P > 0.05$) on live weight, daily weight gain, feed conversion ratio and mean weight gain in the whole period. However, the consumption of diets containing 30% of pistachio shells causes a significant reduction ($P < 0.05$) in all of the

above-mentioned areas. According to the results obtained, consumption of dried pistachio shell up to a maximum of 20% in the diet of fattening lambs can be recommended[15]. Karian et al have used pistachio cellulose skin in preparing natural polymers. Their results have indicated that by increasing the amount of pistachio cellulose husk flour from 30 to 50%, tensile and flexural strength, flexural modulus, percentage of elongation at tensile fracture point, and water absorption of composite increased. However, tensile modulus, impact resistance and thickness swelling decreased by increasing the amount of pistachio cellulose husk flour[16].

2. Conclusion

Given the characteristics of pistachio skin, its applications and the amount of its production in different cities of Iran, it seems necessary to conduct studies and planning to determine the optimal use of its potentials and the ability to commercialize these applications. Considering the properties of materials obtained from pistachio skin, especially those used in industry and pharmaceutical applications, it can be stated that investing in the pistachio market is not only an active and dynamic investment, but given the increased pistachio prices in the current market, it is also an early-return investment with a low risk.

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