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Review Article

Orange Peel: A comprehensive Review on Residue Properties

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ABSTRACT

The peel of the sweet orange (*Citrus sinensis*) is often discarded, but it actually holds significant nutritional and medicinal value. Recent studies suggest that orange peel is rich in bioactive compounds and may offer several health benefits. This article aims to highlight its chemical components, biological activities, and possible future applications, encouraging further scientific exploration. Sweet orange peel contains many useful substances such as essential oils, flavonoids, carotenoids, steroids, terpenoids, alkanes, and ethyl esters. These compounds are known for their strong antioxidant properties, which help the body fight oxidative stress caused by free radicals. Both laboratory and animal studies have shown that extracts from orange peel can reduce oxidative damage and may help in lowering the risk of chronic illnesses, including cancer. Apart from its antioxidant effects, orange peel also shows antimicrobial potential. Some of its natural compounds have been found to act against harmful bacteria and fungi, making it a promising natural source for disease prevention and health improvement.

INTRODUCTION

Sweet orange is considered one of the most beloved and popular fruits worldwide. Its sweet taste when ripe is a unique attraction for consumption by people of all ages, from children to adults. This has led to a large market demand, automatically increasing the commodity value for this plant. The global production of oranges is estimated at 115 million tons each year. Another reason why sweet oranges are a preferred choice

for consumption is the presence of active compounds such as phenolics, flavonoids, carotenoids, vitamin C, and polysaccharides, which play crucial roles in human nutrition. Additionally, it contains folate and thiamine (vitamin B), contributing to nutritional needs. The high level of sweet orange production poses another problem, namely that the consumed part of the fruit is only the flesh, leaving the fruit peel as a significant waste. If not properly managed, this large amount of waste can contribute to

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environmental pollution. However, this overlooked fruit peel still contains active compounds comparable to the fruit flesh. Several studies have been reported on the peel of sweet oranges, covering chemical components such as essential oils, flavonoids, carotenoids, steroids, terpenoids, alkane groups, and ethyl esters. Additionally, pharmacological activities including antioxidant, anticancer, antimicrobial, and anti-inflammatory properties have been investigated.

What is powdered Orange Peel?

Natural herbal Orange peel powder can be used to treat a variety of illnesses and achieve attractive skin. It has much more vitamins, minerals, and other nutrients than the Orange itself.



Fig 1: Orange Peel

Solvent Extraction

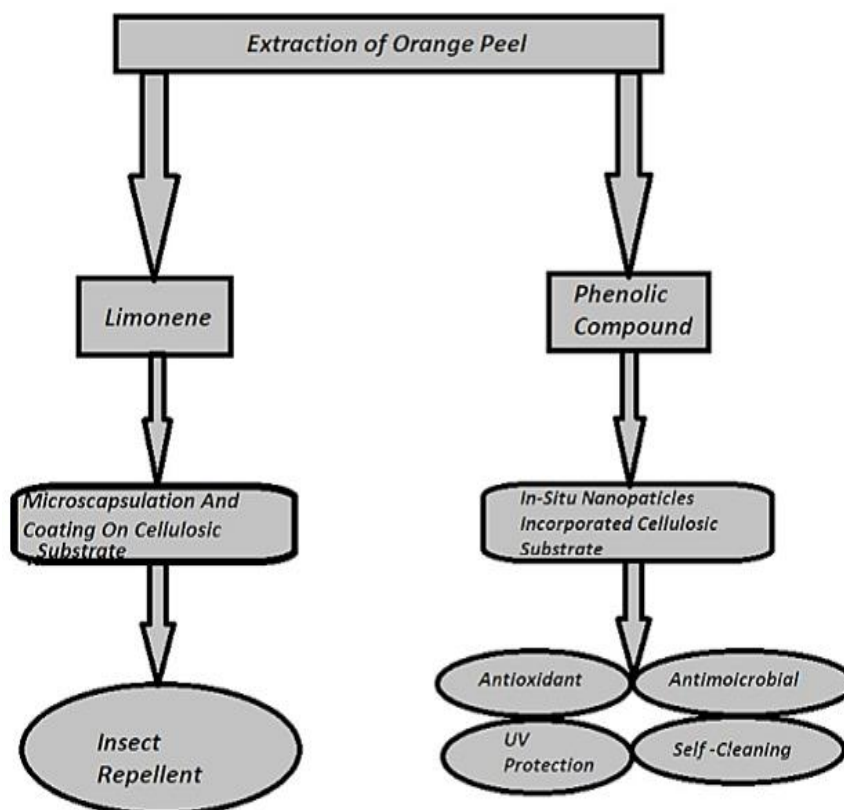
Orange peel powder (100 g) was subjected to extraction using different solvents hexane, methanol, and acetone. The Soxhlet extraction technique was employed, operating for five hours at a constant temperature of 50 °C, using 750 ml of each solvent. After the extraction process, the mixtures were filtered through Whatman No. 2 filter paper to remove any residual peel particles.

The resulting filtrates were then concentrated using a rotary evaporator under reduced pressure at 60 °C until completely dried. The dried extracts were transferred into clean glass containers and stored in a refrigerator at 4 °C until further use.

Aqueous Extraction

For the water-based extraction, a slightly modified method was applied. In this case, 15 g of orange peel powder was soaked in 200 ml of distilled water and kept at room temperature for 24 hours with continuous shaking. After soaking, the mixture was filtered using Whatman No. 1 filter paper. The filtrate was then dried using a water bath maintained at 70 °C.

The yield of the dried aqueous extract was measured using an analytical balance. The final extract was stored in glass vials and kept at 4 °C until further analysis.



Chemical Composition of Orange Peel

The chemical makeup of volatile oils in orange plants varies notably depending on the part of the plant. Significant differences are observed among the flowers, leaves, and the peel.

Specifically, the peel contains several key compounds, including:

- Linalyl acetate – comprising approximately 50% of the volatile oil content
- Linalool – around 35%
- Limonene – a major monoterpene present in notable quantities
- D-limonene – another dominant compound contributing to aroma and biological activity
- Folic acid – a vital vitamin found in small amounts

- Hesperidin – a flavonoid known for its antioxidant and anti-inflammatory properties
- Naringin – another important flavonoid with potential health benefits

Evaluation of Antimicrobial Activity of Citrus Peel and Pulp Extracts

In Vitro Antibacterial Testing

The antibacterial potential of the citrus peel and pulp extracts was assessed using the well diffusion method. Bacterial strains were cultured in nutrient agar medium (NAM) and nutrient broth, with each culture grown in separate sterile test tubes. These were inoculated with different bacterial strains and incubated at 37 °C for 48 hours to allow for bacterial growth.

As a positive control, ampicillin (1 mg/ml) was used to compare the effectiveness of the extracts. Once the molten agar had been poured into

sterilized Petri dishes and solidified, 1 ml of bacterial inoculum was added to each plate. After the medium solidified, wells were created using a sterile borer or needle. Each well was then filled individually with different solvent extracts of citrus peel and pulp.

In Vivo Evaluation in Mice

To assess biological activity in live subjects, in vivo testing was conducted using laboratory mice. The citrus peel extracts were dissolved in 2% Tween 80 solution and administered via intravenous injection (IV) through the tail vein while the mice were lightly anesthetized with ether.

Two sets of experiments were conducted:

1. Time-Dependent Study: Three groups of mice were administered either 10 mg/kg of the orange peel extract, heparin, or saline (as control). Blood was collected at 0.5, 1, 2, and 3 hours after the administration of the test substances or control treatments.

Additional Biological Properties of Orange Peel

Laxative Properties

In traditional Chinese medicine, a formulation combining *Citrus aurantium*, *Magnolia officinalis*, and species from the *Rheum* genus was distilled and evaluated for its laxative effect. The preparation demonstrated notable activity, likely due to the synergistic action of its multiple herbal components.

Antifungal Activity

Research conducted in Paraguay employed the agar plate method to test the antifungal potential of essential oils derived from orange peel against various plant pathogenic fungi. The results

indicated effectiveness against fungi such as *Lenzites trabea*, *Lentinus Lepidus*, and *Polyporus versicolor*.

In contrast, a study performed in Egypt using the same agar plate technique revealed that the essential oil showed no significant activity against *Penicillium cyclopium* and *Trichoderma viride*, highlighting variability in antifungal effectiveness depending on the fungal strain and geographical source of the oil.

The antioxidant potential of orange peel extract (OPE) has been evaluated using three commonly applied chemical assays: DPPH, ABTS, and ORAC.

Antioxidant Activity

- The ORAC (Oxygen Radical Absorbance Capacity) assay is based on hydrogen atom transfer (HAT) mechanisms and is particularly useful for assessing the ability of antioxidants to break free radical chain reactions.
- In contrast, both DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)) rely on electron transfer (ET) to measure the capacity of compounds to donate electrons and neutralize free radicals.

These assays are widely utilized to determine the antioxidant properties of various food substances and biological extracts, including citrus peel.

Other Applications of Orange Peel

Peel, particularly in its powdered and aqueous extract forms, has been utilized in various innovative applications due to its rich composition of bioactive compounds.

Use in Biofilm Enhancement



Both orange peel powder and its aqueous extract have been incorporated into carboxymethylcellulose (CMC) edible films to improve their physical strength and antioxidant capacity. The resulting biofilm formulation includes 1.7% aqueous extract and 3.3% peel powder, significantly increasing the content of phenolic compounds and flavonoids. These natural additives enhance the film's functionality for potential use in food packaging.

Biopolymer Production from Mucilage

The mucilage extracted from orange peel has been used to produce a biodegradable polymer. This material exhibits excellent properties such as:

- High water solubility
- Foaming and emulsifying ability
- Thermal stability up to 250 °C

These characteristics make it suitable for the development of eco-friendly containers and packaging materials.

Environmental Applications

Crude orange peel powder (CPP) has proven effective in treating wastewater. Due to its high biosorption capacity, it can remove:

- Heavy metals
- Synthetic dyes
- Pesticides
- Suspended solids causing turbidity

Remarkably, using just 0.5 g of orange peel powder with a particle size of 10 mm has shown significant decontamination efficiency, making it

a low-cost and sustainable solution for water purification.

Health Benefits of Orange Peel

Orange peel powder is a rich source of vitamin C, a crucial nutrient for skin health. It supports the synthesis of collagen and elastin, two structural proteins essential for maintaining firm, smooth, and youthful skin. Its regular use in skincare formulations can contribute to improved skin tone and elasticity.

Health Benefits of Orange Peel

Orange peel is known for its wide range of potential health-promoting properties. Some of its notable benefits include:

• Supports Digestive Health

Orange peel helps improve digestion by stimulating the production of digestive enzymes, which can lead to better nutrient absorption and relief from bloating and gas.

• Aids in Weight Management

Rich in dietary fibre and low in calories, orange peel can contribute to a feeling of fullness, which may help in controlling appetite and supporting weight loss efforts.

• Helps Alleviate Allergies

Compounds in orange peel may have natural antihistamine properties, assisting in reducing allergy symptoms by modulating immune responses.

• Shows Potential in Cancer Prevention

Due to its high content of flavonoids and antioxidants, orange peel has shown promise in



studies for its potential to help protect cells from damage and reduce cancer risk.

- **Promotes Healthy Skin**

With its abundance of vitamin C and antioxidants, orange peel supports collagen production and can improve skin texture, tone, and elasticity.

- **Combats Bad Breath**

Its natural antibacterial properties help fight odor-causing bacteria in the mouth, making orange peel a natural remedy for freshening breath.

- **Reduces Inflammation**

The anti-inflammatory compounds in orange peel may help reduce inflammation in the body, offering relief in conditions such as arthritis.

- **Supports Heart Health**

Orange peel contains hesperidin and other flavonoids that may contribute to improved circulation and lower cholesterol levels, benefiting cardiovascular health.

- **Acts as a Natural Choleragogue**

Orange peel may help stimulate bile flow from the liver, supporting the digestive process and liver function.

- **Enhances Libido**

Traditionally, orange peel has been considered to have mild aphrodisiac properties, potentially supporting sexual health and vitality.

- Beneficial for Pregnant and Breastfeeding Women

Rich in essential nutrients like vitamin C, folate, and calcium, orange peel can be supportive during

pregnancy and lactation, though it should be consumed in moderation and under guidance.

Scope of the Study

This study opens the door for further investigation into the specific chemical constituents responsible for this antimicrobial effect.

Through detailed research, it may become possible to identify and isolate the exact compounds contributing to the inhibition of different bacterial strains. Once these active components are clearly understood, they could be used to develop targeted, cost-effective formulations for pharmaceutical or therapeutic purposes.

Additionally, this research could pave the way for the synthesis of artificial analogues that mimic the structure and function of these natural compounds, providing an alternative source for the antibacterial activity observed in citrus fruit peels. It is likely linked to the presence of various bioactive antioxidant compounds, antimicrobial agents derived from plant-based materials.

Commercial Production and Uses of *Citrus sinensis*

Oranges (*Citrus sinensis*) are widely cultivated in warm climates and are highly favoured for their refreshing taste and aromatic qualities. They are not only consumed as fresh fruit but are also processed into a variety of commercial products used across food, cosmetic, and medicinal industries.

1. Fruit Usage for use in cakes, cookies, and other baked goods.

2. Peel Applications

Orange peel is rich in



The fruit can be sliced, dried, and ground into a fine powder, which is often used as a flavour enhancer in bakery products. Its tangy, citrusy profile makes it ideal

essential oils and aromatic compounds, making it valuable in the fragrance and personal care industry. It is commonly used in the production of perfumes, soaps, creams, and other skincare products. Its natural cleansing and toning properties help detoxify and refresh the skin, which is why it is frequently included in cosmetic formulations.

3. Juice and Culinary Uses

Orange juice is a popular ingredient in fruit salads, desserts, gelatin dishes, cakes, and is sometimes used as a garnish for meat and poultry. The pulp is mainly used for fresh juice production, known for its high nutritional value. In 1963, dehydrated orange juice was developed and continues to be used in the food industry to improve the flavour, nutritional content, and colour of various food products, particularly in baked items.

4. Traditional and Medicinal Uses

The juice extracted from the leaves of the orange tree has traditionally been used to help treat ulcers and skin sores. Moreover, *Citrus sinensis* has been associated with beneficial effects in managing a wide range of health conditions including:

- Arthritis
- Asthma
- Alzheimer's disease
- Parkinson's disease

- Macular degeneration
- Diabetes mellitus
- Gallstones
- Multiple sclerosis
- Cholera
- Gingivitis
- Cataracts
- Crohn's disease
- Ulcerative colitis
- Lung function improvement

5. Nutritional Value

Oranges are naturally low in calories, contain no saturated fat or cholesterol, and are an excellent source of dietary fibre and pectin.

- Pectin acts as a bulk-forming laxative and helps maintain colon health by protecting the mucosal lining.
- Oranges are especially rich in vitamin C, offering approximately 48.5 mg per 100 g, which is around 81% of the Daily Recommended Intake (DRI). Vitamin C boosts immune function, offers antioxidant protection, and supports the body's defence against infections.

The peel of the orange also contains compounds known to help lower cholesterol levels and cleanse the internal systems of the body. Essential minerals like potassium and calcium are also present in the fruit.



- Potassium is crucial for maintaining fluid balance and regulating heart rate and blood pressure by countering the effects of sodium.

6. Therapeutic Use of Skin and Juice

The peel (skin) of *Citrus sinensis* has traditionally been used to:

- Stimulate appetite
- Reduce mucus (phlegm)
- Treat coughs, colds, gas, indigestion, and even some types of based as following.

Traditional Uses of Sweet Orange (*Citrus sinensis*)

Sweet orange has been appreciated in various cultures not only for its pleasant flavour and aroma but also for its traditional medicinal and symbolic uses.

- In Japanese culture, orange blossoms are traditionally viewed as symbols of purity and chastity, often associated with ceremonial use.
- In Arab traditions, orange blossom extracts have been used as a natural dye to cover grey hair, showcasing their role in traditional personal care practices.
- Across multiple regions, both the pulp and flowers of sweet orange have historically been incorporated into cosmetic preparations due to their skin-refreshing and aromatic qualities.
- Orange juice has long been consumed as a general tonic, appreciated for its ability to relieve stress, promote relaxation, and support hydration.
- In Mexican folk medicine, oranges were traditionally used to help treat tuberculosis,

reflecting their perceived value in supporting respiratory health.

- In France, sweet oranges were commonly used in traditional remedies to manage a variety of conditions including:
 - Angina (chest pain)
 - Constipation
 - Menstrual irregularities
 - High blood pressure (hypertension)
- The fruit has been commonly associated with relief from constipation, likely due to its natural fibre content.
- In Traditional Chinese Medicine, oranges are viewed as a cooling food, often used to soothe coughs, colds, and other respiratory problems. Beyond their medicinal role, oranges are also culturally significant in China, often symbolizing good fortune and prosperity.

Nutritional Value of *Citrus sinensis*

Sweet oranges are not only flavourful but also nutritionally beneficial, contributing to a healthy diet in multiple ways:

- A single orange can provide approximately 12.5% of the daily recommended intake of dietary fibre, which is essential for digestive health.
- The fibre content in oranges has been shown to assist in lowering high cholesterol levels, thereby playing a role in preventing atherosclerosis (hardening of the arteries).
- Fiber also contributes to blood sugar regulation, making oranges a suitable snack option for individuals with diabetes. The



presence of fructose, a natural sugar found in oranges, helps prevent sharp spikes in blood sugar levels after eating.

- In terms of cancer prevention, the dietary fibre in oranges may bind to and help eliminate carcinogenic substances, reducing their contact with the cells in the colon.
- Sweet orange may also help alleviate symptoms of irritable bowel syndrome (IBS), including constipation and diarrhoea, due to its gentle impact on digestive function
- **Nutrient composition of sweet orange.**

Orange Peels and Heart Health Benefits :

The saying "an apple a day keeps the doctor away" is well-known, but recent research suggests that orange peels may also offer significant benefits for heart health. Yu Wang, an assistant professor specializing in food science and human nutrition at the University of Florida's Institute of Food and Agricultural Sciences, has received a \$500,000 grant from the U.S. Agriculture and Food Research Initiative (USDA) to explore this potential.

Wang aims to lead a research team focused on investigating how extracts from orange peels can enhance gut health and help prevent the buildup of fatty deposits inside arteries, a condition known as atherosclerosis. Scientific studies have indicated that gut bacteria play a critical role in the development of cardiovascular diseases. During digestion, these bacteria break down certain nutrients, producing a compound called trimethylamine N-oxide (TMAO). Elevated TMAO levels have been identified as strong indicators of future heart disease risk by researchers at the Cleveland Clinic

Wang and her colleagues intend to examine the relationship between orange peel consumption and gut bacteria, aiming to understand how orange peels might improve overall health by influencing gut microbiota. Currently, the United States produces approximately five million tons of orange peels annually, which are largely discarded as waste. However, the Food and Drug Administration (FDA) recognizes natural orange peel extracts as safe for human use. Wang sees an opportunity to repurpose these peels in beneficial ways.

The researchers focus on how orange peels might modify gut bacteria to prevent atherosclerosis. Gut microbes break down compounds like choline and carnitine, generating trimethylamine (TMA). This TMA is then converted by enzymes into TMAO, a molecule linked to artery plaque formation. Interestingly, orange peels contain substances that inhibit the enzymes responsible for this conversion, potentially reducing TMAO levels and lowering heart disease risk.

To validate these ideas, Wang's team will use a combination of animal experiments and enzyme studies to observe how orange peel extracts affect cardiovascular health. In preliminary experiments, Wang tested three groups of mice: one on a normal diet, another on a normal diet supplemented

with carnitine (which increases TMAO production), and a third group fed a normal diet with both carnitine and orange peel extracts. The results showed that the orange peel intake changed the bacterial makeup in the mice's colons, suggesting a beneficial effect.

Wang expects that within three years, her team will have a clearer understanding of how orange peel consumption impacts TMAO production and helps prevent atherosclerosis. She hopes the findings will not only advance heart health through



gut microbiota improvements but also promote a practical use for orange peels that are currently discard

CONCLUSION:

With the growing public focus on healthy living and the increasing demand for functional foods, the use of sweet orange fruit peel offers a promising opportunity. The peel contains various bioactive compounds, including essential oils, flavonoids, steroids, and terpenoids, which have been shown to possess significant pharmacological properties. These include antioxidant, anticancer, antimicrobial, anti-inflammatory, and anti-osteoporotic effects. Consequently, sweet orange peel holds potential as a natural ingredient in herbal medicine, often considered safer and less harmful than synthetic pharmaceuticals. Both the powdered form and extracts of the peel can be utilized as food preservatives due to their ability to inhibit microbial growth, thereby extending the shelf life of food products. Additionally, their antioxidant properties make them suitable for use in sun protection formulations. Furthermore, the anticancer potential of sweet orange peel presents a cost-effective alternative to traditional chemotherapy, which is often costly and associated with severe side effects.

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