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Sweet Orange Pomace: A Potential Source of Functional Ingredients for Food Applications

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Abstract
Sweet orange pomace a major by-product of citrus juice industries, is increasingly gaining attention as a valuable source of bioactive compounds and dietary fibre. Traditionally considered waste, this agro-industrial residue presents significant potential for functional food applications due to its rich nutritional profile, including antioxidants, pectin, polyphenols, flavonoids, and essential oils. This review explores the composition, extraction techniques, functional properties, and diverse food applications of sweet orange pomace. The paper also examines its implications on health, environmental sustainability, and its role in the development of novel food products.

Keywords: Sweet orange pomace, Chemical Composition, Dietary Fibre

Introduction

India is the world's second largest producer of fruits, with annual production reaching approximately 108.34 million tons in financial year 2022-23. Out of total production 76% fresh fruits were consumed, 4% is used for processing and estimated 20-22% is lost as waste due to improper post-harvest handling. The processing of fruits create considerable waste, including peel, seeds and other residue (NHB, 2022; ICAR, 2012). Typically, fruits are processed to produce pulps, juices, ready to serve beverages, canned fruits, jams, squashes, marmalades and utilized for extracting flavonoids, pectin and essential oils. The leftover material after juice extraction, known as pomace, poses disposal challenges, especially with increasing legal restrictions. However, these byproducts can be valuable, offering nutrients, dietary fibre and also significant levels of colorants, antioxidants or other beneficial compounds (Schieber et al., 2001). The recovery of dietary fibres from sweet orange pomace not just minimized the waste of fruit processing industry but also contribute to isolation of health promoting food ingredient from this waste and used in formulation of fibre enriched food products. Besides, citrus fibres are noticed for their good water holding capacity, swelling capacity and emulsifying property, that make them suitable for value addition in bakery products, dairy products and meat analogues (Grigelmo and Martin 1999).

Composition of Sweet Orange Pomace

Sweet orange pomace is composed of several valuable constituents. Dietary fibre, both soluble and insoluble fibers like pectin, cellulose and hemicellulose are abundantly present. These aid in digestive health, cholesterol management, and glycemic control (Saikia et al., 2015). Polyphenols and flavonoids:

Including hesperidin, narirutin, and naringin, which offer antioxidant, anti-inflammatory, and anti-carcinogenic benefits (Li et al., 2022). Essential oils extracted from sweet orange waste mainly d-limonene, contributing to antimicrobial and preservative properties. It is good source of vitamins and minerals particularly Vitamin C, potassium, calcium, and magnesium.

Extraction and Processing Techniques

Effective utilization of sweet orange pomace requires optimal extraction methods to recover valuable compounds. Several methods including alkali, acid, solvent, enzymatic and ultrasound-assisted extraction were used to extract dietary fibres with their desirable properties (Wang et, al., 2021). Milling and sieving come under mechanical extraction and used to obtain fibre-rich fractions. In solvent extraction method polar solvents like ethanol and methanol help isolate phytochemicals, polyphenols and flavonoids. Microwave-assisted and ultrasound-assisted extraction are the novel techniques used to enhance yield and preserve bioactivity of chemical compound (Goula et al., 2012). Enzymatic treatment used for releasing pectin and improving functional properties. Drying and grinding essential for converting sweet orange pomace into powder for easy incorporation in food products.

Role of functional Properties of sweet orange pomace powder in food application

Sweet orange pomace imparts various functional benefits when used as a food ingredient. Water and oil holding capacity of sweet orange pomace helps in enhancing texture and shelf life in bakery and meat products. Emulsifying ability property of sweet orange pomace useful in sauces and dressings for texture stabilization. Due to high pectin content, it possesses gelling and thickening properties (Silva et al., 2020). Antioxidant activity of sweet orange pomace reduces oxidative stress and enhances product stability. Sweet orange pomace also has prebiotic effects that promotes the growth of beneficial gut microbiota (Araujo et al., 2014).

Applications of Sweet Orange Pomace in the Food Industry

Sweet orange pomace, a by-product of juice processing, has gained increasing attention as a functional ingredient in various food formulations due to its high fibre, pectin, and bioactive compound content. Incorporation of orange pomace powder in bakery products such as cakes, biscuits, and breads enhances the fibre, mineral, and antioxidant content while improving texture and moisture retention due to its excellent water-holding and oil-binding capacities (Kumar et al., 2021; Carvalho et al., 2022).

It can also serve as a natural fat replacer in bakery and confectionery items, contributing to calorie reduction and better nutritional profiles (Chelliah et al., 2020). The presence of high pectin content imparts gelling and thickening properties, making orange pomace suitable for use in jams, sauces, and dressings for texture stabilization (Ysabel et al., 2015). Furthermore, the rich phenolic and flavonoid content of sweet orange pomace provides strong antioxidant activity, which helps in reducing oxidative stress and improving the shelf life of food products (Silva et al., 2020; Araujo et al., 2014).

Recent studies have also demonstrated its prebiotic potential, as pectic oligosaccharides derived from orange pomace promote the growth of beneficial gut microbiota such as *Lactobacillus* and *Bifidobacterium* species (Araujo et al., 2014; Dah-Phong et al., 2023). Overall, sweet orange pomace is emerging as a sustainable and value-added ingredient for the development of fibre-enriched, antioxidant-rich, and health-promoting functional foods.

Health Benefits of Sweet Orange Pomace

Sweet orange pomace, a major by-product of juice processing industries, exhibits several health-promoting properties due to its rich content of dietary fibre, polyphenols, flavonoids, and pectic substances. The high concentration of phenolic compounds contributes significantly to its antioxidant activity, which helps neutralize free radicals and reduce oxidative stress, thereby protecting against chronic diseases (Silva et al., 2020; Guimarães et al., 2021). Additionally, bioactive compounds from orange pomace possess anti-inflammatory effects, as they suppress nitric oxide and inflammatory cytokine production in macrophage models (Yousaf et al., 2021). The soluble dietary fibre and pectin present in orange pomace aid in regulating blood glucose levels by delaying glucose absorption and lowering postprandial insulin responses, as demonstrated in human studies (Schmidt et al., 2016). Moreover, the incorporation of orange pomace into foods has been shown to enhance satiety and promote appetite control, contributing to better weight management (Mermelstein et al., 2017).

Due to its rich fibre and pectic oligosaccharide content, sweet orange pomace also exhibits prebiotic potential, stimulating the growth of beneficial gut microbiota such as *Lactobacillus* and *Bifidobacterium* species (Araujo et al., 2014; Dah-Phong et al., 2023). Overall, these properties make sweet orange pomace a valuable ingredient for the development of functional foods aimed at improving digestive health, reducing oxidative stress, and supporting metabolic well-being.

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Potential outlook

Microencapsulation of sweet orange pomace extracts commercialized for use in functional supplements can be done for commercial applications. Sweet orange pomace will be used in biodegradable packaging films due to antimicrobial and antioxidant properties. Sweet orange pomace derived ingredients in functional foods targeting specific health conditions. It can be used as prebiotic formulation for enhancing gut-health.

Conclusion

Sweet orange pomace, a largely underutilized by-product, holds immense potential in the development of functional foods owing to its rich composition of fiber, antioxidants, and phytochemicals. With advancements in extraction and food processing technologies, SOP can be effectively integrated into various food matrices to improve nutritional quality and sustainability. Future research should focus on improving sensory attributes, bioavailability of active compounds, and consumer acceptance to support commercial utilization.

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