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REVIEW

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Dietary sources of pterostilbene: Beyond blueberries

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ABSTRACT

Pterostilbene, a naturally occurring polyphenol, has garnered attention for its potent antioxidant, anti-inflammatory, and potential therapeutic properties. While blueberries are well-known as the primary dietary source, recent research has revealed its presence in other foods such as grapes, cranberries, nuts, and seeds. This review explores the chemical properties, bioavailability, and metabolic pathways of pterostilbene, emphasising its stability and superior absorption compared to its analogue, resveratrol. Additionally, the health benefits associated with its consumption are critically analysed, highlighting its roles in combating oxidative stress, reducing inflammation, and offering potential therapeutic effects against chronic diseases such as diabetes and cancer. Emerging dietary sources, including plant-based supplements, are discussed as alternative means to increase intake. The paper also provides practical dietary recommendations for incorporating pterostilbene into everyday nutrition and identifies gaps in current research, advocating for future studies to optimise its use as a functional food component. By expanding the focus beyond blueberries, this review underscores the broader dietary potential of pterostilbene in promoting health and preventing disease.

KEYWORDS

Pterostilbene; Dietary sources; Antioxidant properties; Bioavailability; Nutritional supplements; Chronic disease prevention

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Introduction

Pterostilbene, a natural stilbenoid predominantly found in blueberries, is structurally similar to resveratrol but exhibits enhanced bioavailability and stability due to its two methoxy groups. This compound demonstrates a wide range of pharmacological properties, including antioxidant, anti-inflammatory, antidiabetic, and anticancer effects. Pterostilbene's superior lipophilicity contributes to its improved intestinal absorption, cellular uptake, and biological potency compared to resveratrol. Research has shown that pterostilbene modulates various signaling pathways, affecting cell cycle regulation, apoptosis, autophagy, and tumor angiogenesis [1]. Its potential therapeutic applications extend to cardiovascular disorders, neurodegenerative conditions, and aging-related diseases [2]. The compound's promising health benefits and favorable safety profile make it an attractive subject for nutritional and medical research.

Blueberries have traditionally been the main dietary source of pterostilbene, leading to the belief that they are the sole significant source. However, recent studies indicate that pterostilbene can be present in various other foods, such as grapes, cranberries, peanuts, and certain herbs [3]. These sources provide a range of dietary options for individuals who want to include pterostilbene in their diet and potentially improve their overall health. Recognizing the wider dietary variety of pterostilbene-rich foods is essential for encouraging its consumption and maximizing its health benefits.

It is crucial to explore the metabolism and bioavailability of pterostilbene in addition to investigating its dietary sources to gain a better understanding of how it affects health. Although pterostilbene is efficiently absorbed in the gastrointestinal tract, its bioavailability can be affected by factors such as food matrix and interaction with gut microbiota. Research has shown that pterostilbene undergoes metabolic changes in the liver, which can impact its effectiveness for therapeutic purposes [4].

This brief review aims to comprehensively explore the dietary sources of pterostilbene, going beyond the commonly known blueberries, and emphasizing the importance of identifying other significant contributors to its consumption. By examining the composition of different foods and their pterostilbene content, this review seeks to offer insights into how a varied diet can enhance pterostilbene intake and potentially promote its health benefits.

Chemical Properties and Bioavailability of Pterostilbene

Chemical structure

Pterostilbene (trans-3,5-dimethoxy-4′-hydroxystilbene) is a dimethyl ether analog of resveratrol, differing from it primarily by the presence of two methoxy groups at the 3 and 5 positions of the phenolic ring, which improve its lipophilicity and stability. This modification increases lipid solubility, facilitating enhanced absorption in biological systems [5]. Compared to resveratrol, which has a hydroxyl group at the 3 positions, pterostilbene exhibits greater chemical stability, particularly in resisting oxidative degradation. The increased stability is attributed to its unique structure, rendering it a more viable candidate for therapeutic applications, especially in conditions like cancer and cardiovascular diseases.

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Bioavailability and metabolism

Pterostilbene is significantly more bioavailable than resveratrol, with studies indicating bioavailability rates of approximately 80%, compared to around 20% for resveratrol. This higher bioavailability can be attributed to its efficient absorption in the intestines and prolonged circulation time due to its lower rate of metabolism [6]. Upon oral administration, pterostilbene undergoes extensive metabolism in the liver, primarily via glucuronidation and methylation. Factors influencing its bioavailability include the formulation and food matrix consumed; for instance, the presence of lipids in food can enhance absorption by improving solubility. Moreover, novel delivery methods, such as cocrystal formulations, have been developed to further improve pterostilbene's solubility and stability, thus enhancing its bioavailability.

Traditional Dietary Sources of Pterostilbene

Blueberries

Blueberries (*Vaccinium* spp.) are recognized for their substantial concentration of pterostilbene, a stilbene compound structurally similar to resveratrol but with enhanced bioavailability and bioactivity. Research indicates that the pterostilbene content in blueberries ranges from 0.02 to 0.06 mg/g, which supports their classification as a functional food [7]. Beyond their pterostilbene content, blueberries are rich in other phenolic compounds, vitamins, and minerals, which collectively support cardiovascular health and exhibit anti-inflammatory properties. Several studies suggest that regular consumption of blueberries is associated with improved cognitive function and a lower risk of age-related diseases, such as Alzheimer's. The health benefits associated with blueberries arise from their ability to combat oxidative stress and inflammation, two critical pathways implicated in chronic diseases.

Other berry species

Pterostilbene is not exclusive to blueberries; other berry species also contribute to dietary intake. For instance, strawberries (Fragaria × ananassa) and blackberries (*Rubus fruticosus*) contain varying amounts of pterostilbene, although their concentrations are generally lower than those found in blueberries. Strawberries typically contain around 0.01 mg/g, while blackberries have been reported to have similar concentrations. Additionally, cranberries (*Vaccinium macrocarpon*) are notable for their presence of bioactive compounds, including pterostilbene, although in lesser quantities relative to blueberries. Comparative analyses highlight that while the pterostilbene content in these berries may be lower, their consumption continues to offer health benefits due to their overall rich phytochemical profiles and antioxidant properties. Inclusion of various berries in the diet is recommended for their potential synergistic effects on health, particularly in enhancing cardiovascular and metabolic health [8].

Grapes and wine

Grapes (*Vitis vinifera*) represent a notable source of pterostilbene, especially in red wine. Various grape varieties have shown differing levels of pterostilbene, with concentrations ranging from 0.01 to 0.04 mg/g, influenced by grape ripeness and cultivation conditions. Winemaking processes, including fermentation and aging, can further impact the levels of pterostilbene in wine. For example, red wines generally exhibit greater concentrations of pterostilbene than white wines due to the skin contact during fermentation, which allows for greater extraction of polyphenolic compounds [9]. The consumption of grapes and grape products, such as wine, is associated with various health benefits, primarily due to their polyphenolic content, notably resveratrol and pterostilbene. The synergy between these compounds in grapes underscores their value as functional foods within a balanced diet.

Emerging Dietary Sources of Pterostilbene

Nuts and seeds

Pterostilbene, a stilbene compound primarily found in blueberries and grapes, has been identified in several nuts and seeds, notably in almonds and walnuts. Almonds, for instance, contain approximately 1.2 to 2.5 µg of pterostilbene per gram, while walnuts have shown comparable levels as well. These nuts are not only rich in pterostilbene but also provide a variety of essential nutrients, including healthy fats, protein, and dietary fiber, which collectively support overall health.

The health benefits associated with the consumption of these nuts and seeds are significant. Research indicates that pterostilbene possesses antioxidant, anti-inflammatory, and potential anti-cancer properties [10]. For instance, studies suggest that pterostilbene may lower LDL cholesterol levels, enhance cardiovascular health, and support metabolic functions. Moreover, the presence of pterostilbene in these food sources underscores the importance of incorporating nuts and seeds into a balanced diet, as they may synergistically enhance health outcomes when integrated into a regular dietary pattern.

Other fruits

Beyond traditional sources like blueberries, various other fruits are emerging as notable dietary sources of pterostilbene. Cranberries and mulberries are two noteworthy examples, with cranberries containing approximately 0.1 to 0.5 µg per gram. Mulberries, particularly black mulberries, have demonstrated higher pterostilbene concentrations, potentially comparable to that of blueberries.

These fruits not only offer pterostilbene but are also rich in vitamins, minerals, and antioxidants, contributing to overall health. The consumption of fruits high in pterostilbene has been linked to various health benefits, including improved cardiovascular health, enhanced cognitive function, and protective effects against chronic diseases. A comparative analysis of pterostilbene levels in different fruit varieties highlights the potential benefits of integrating diverse fruit sources into the diet, thereby maximizing antioxidant intake and promoting overall health [11].

Plant-based supplements

Plant-based supplements containing pterostilbene are gaining popularity due to their potential health benefits. These supplements typically come in the form of capsules, tablets, or powders and are marketed for their antioxidant and anti-inflammatory properties. They offer an alternative for individuals wishing to increase their pterostilbene intake beyond food sources.

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However, considerations regarding the efficacy and safety of these supplements are crucial. Although pterostilbene supplements can deliver significant health benefits, their bioavailability may differ in comparison to natural food sources. Furthermore, recommended dosages range between 50 and 250 mg per day, with some individuals experiencing gastrointestinal issues or allergic reactions at higher doses [12]. Therefore, consumers must consult healthcare providers before incorporating pterostilbene supplements into their regimens to ensure the safe achievement of optimal health outcomes.

Antioxidant properties

Pterostilbene, a polyphenolic compound, demonstrates significant antioxidant properties primarily through its ability to scavenge free radicals and enhance the body's endogenous antioxidant systems. Its chemical structure, specifically the dimethoxy groups, contributes to its potency in comparison to other stilbenes, such as resveratrol [13]. Research has shown that pterostilbene can increase the expression of key antioxidant enzymes, including superoxide dismutase and glutathione peroxidase, which play a crucial role in mitigating oxidative stress. A study demonstrated the effectiveness of pterostilbene in reducing oxidative damage in various cellular models, reinforcing its potential role in the prevention of diseases associated with oxidative stress, including cardiovascular conditions and neurodegenerative disorders.

Anti-Inflammatory effects

The anti-inflammatory effects of pterostilbene are well-documented. It modulates several inflammatory pathways, primarily by inhibiting the nuclear factor-kappa B (NF-κB) pathway, which is pivotal for the expression of pro-inflammatory cytokines. Studies have indicated that pterostilbene can significantly decrease markers of inflammation, such as interleukin-6 and tumor necrosis factor-alpha, in both in vitro and in vivo experimental models. Furthermore, animal studies have shown that supplementation with pterostilbene decreases inflammatory responses in models of obesity and diabetes, indicating its potential utility in the management of chronic inflammatory conditions [14].

Potential therapeutic applications

The therapeutic applications of pterostilbene encompass various health conditions, including diabetes, cancer, and cardiovascular diseases. Its capacity to enhance insulin sensitivity and lipid profiles makes it a promising candidate for diabetes management. A notable study demonstrated that pterostilbene supplementation led to significant reductions in blood glucose and triglyceride levels in diabetic rats [15]. In oncology, pterostilbene has shown promise in inhibiting cancer cell proliferation and inducing apoptosis in various cancer types, indicating its potential as an adjunctive therapy. Additionally, its cardiovascular benefits, linked to its antioxidant and anti-inflammatory effects, support its use in managing heart diseases, as evidenced by studies indicating improved cholesterol metabolism and reduced blood pressure in participants supplementing with pterostilbene.

In summary, pterostilbene presents a multifaceted approach to health, demonstrating potent antioxidant and anti-inflammatory properties while also holding potential for therapeutic applications in managing chronic diseases. Its favorable safety profile further enhances its appeal as a dietary supplement and functional food component [16].

Practical Implications and Recommendations

Dietary recommendations

To harness the health benefits of pterostilbene, it is recommended that individuals consume dietary sources rich in this compound. Key dietary sources include blueberries, grapes, cranberries, and peanuts, with blueberries being the most significant contributor. On average, blueberries contain approximately 100 to 500 μg of pterostilbene per 100 grams, while other sources offer substantially lower concentrations. Given the low concentration of pterostilbene in most foods, it is essential to incorporate a variety of these fruits and nuts into a balanced diet. This variety enhances overall nutrient intake and maximizes the potential health benefits of pterostilbene [17].

Regarding daily intake, research suggests that a supplemental dose ranging from 200 to 700 mg may be beneficial for health maintenance and the prevention of diseases. However, for individuals relying solely on dietary sources, achieving therapeutic levels can be challenging. Therefore, dietary supplements might be considered to ensure adequate intake, especially for individuals seeking specific health benefits associated with pterostilbene [18].

Future research directions

While current research highlights pterostilbene's promising health effects, several gaps exist in the understanding of its full potential. Future research should prioritize clinical trials to determine the efficacy, safety, and optimal dosages of pterostilbene in humans. Most existing studies have primarily utilized animal models, highlighting the necessity for research that translates these findings into human applications.

Moreover, there is a critical need to explore the pharmacokinetics of pterostilbene, specifically its metabolic pathways and long-term effects in the human body. Understanding its bioavailability and interactions with other compounds will yield valuable insights for the development of effective therapeutic strategies.

Investigating the formulation of pterostilbene-enriched foods or supplements could prove beneficial, as this would help meet the dietary requirements for those seeking to maximize its health benefits. By addressing these gaps, future research can strengthen the evidence for the role of pterostilbene in health promotion and disease prevention, potentially leading to its wider acceptance as a functional food component and therapeutic agent.

Conclusions

This mini-review has emphasized the importance of pterostilbene, a natural stilbenoid with potent antioxidant and anti-inflammatory properties, primarily sourced from blueberries and various other fruits. The various dietary sources of pterostilbene demonstrate its presence in a variety of foods, including nuts, seeds, and plant-based supplements. Its promising health benefits, supported by numerous studies, suggest that it may contribute to the management of conditions

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such as diabetes, cardiovascular diseases, and cancer. This substantial body of research emphasizes the potential of incorporating pterostilbene-rich foods into daily diets to improve health outcomes. Pterostilbene constitutes a significant area of research within the realm of nutrition and health. As the awareness of its health benefits increases, individuals have the opportunity to leverage its potential by consuming a varied diet rich in fruits, nuts, and supplements that provide this beneficial compound. Future studies are essential to better understand its mechanisms of action, optimize dietary intake strategies, and explore the therapeutic applications of pterostilbene in clinical settings. This ongoing research may further reinforce the role of pterostilbene in promoting health and preventing disease, facilitating its broader acceptance as an essential dietary component in health-conscious lifestyles.

Disclosure statement

No potential conflict of interest was reported by the authors.

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