International Journal of
Plant Biotechnology

ISSN: 2456-0162
Volume 10, Issue 2, 2024
July–December
DOI (Journal): 10.37628/IJPB

https://journalspub.com/journal/ijpb/

Review IJPB

The Impact of Phytohormones on Human Metabolism and Wellbeing

Neelesh Kumar Maurya[1,*], Neeti Kushwaha[2], Pratibha Arya[3]

Abstract

Phytohormones, or plant hormones, are vital organic compounds that regulate plant growth, development, and environmental responses. Recent research has shown that phytohormones like auxins, cytokinin, gibberellins, abscisic acid (ABA), ethylene, brassinosteroids, jasmonates, and salicylic acid may also positively impact human metabolism and overall health. Humans are exposed to these hormones primarily through the consumption of fruits, vegetables, and grains, and emerging studies suggest they may influence human metabolic pathways. This review explores the mechanisms by which each phytohormone functions in plants and examines its potential impact on human health, including anti-inflammatory, antioxidant, anticancer, glucose regulatory, and cardiovascular benefits. For instance, ABA improves insulin sensitivity, contributing to diabetes management, while jasmonates and brassinosteroids exhibit anticancer properties by inducing apoptosis in cancer cells. Salicylic acid further contributes to cardiovascular health by attenuating inflammatory responses and inhibiting platelet aggregation, thereby reducing the risk of thrombotic events. Potential therapeutic applications of phytohormones include cancer prevention, diabetes management, cardiovascular support, bone health, and detoxification. However, challenges remain in understanding their bioavailability, optimal dosages, and safety profiles for human use. Furthermore, while initial investigations have yielded promising results, additional large-scale human clinical trials are indispensable to definitively establish efficacy and formulate evidence-based therapeutic protocols. This review emphasizes the potential of phytohormones as natural agents for enhancing metabolic health and provides insights into future research directions needed to integrate these plant-derived compounds into human nutrition and medicine.

Keywords: Phytohormones, metabolism, human health, anti-inflammatory, antioxidant, cancer prevention, glucose regulation, cardiovascular health, bioavailability

***Author for Correspondence**
Neelesh Kumar Maurya
E-mail: neeleshkumar.maurya@gmail.com

[1]Assistant Professor, Department of Nutrition and Dietetics, School of Allied Health Science, Sharda University, Greater Noida, Uttar Pradesh, India
[2]Assistant Professor, Faculty of Humanities and Social Sciences, (INSH), Shri Ramswaroop Memorial University, Deva Lucknow Road, Barabanki, Uttar Pradesh, India
[3]Assistant Professor, Department of Nutrition and Dietetics, Institute of Home Science, Bundelkhand University, Jhansi, Uttar Pradesh, India

Received Date: July 25, 2024
Accepted Date: August 26, 2024
Published Date: October 27, 2024

Citation: Neelesh Kumar Maurya, Neeti Kushwaha, Pratibha Arya. The Impact of Phytohormones on Human Metabolism and Wellbeing. International Journal of Plant Biotechnology. 2024; 10(2): 37–48p.

INTRODUCTION

Phytohormones, or plant hormones, are organic compounds that, while primarily responsible for regulating plant growth, development, and responses to environmental stimuli, also play an impactful role on human health and metabolism. These bioactive compounds, commonly found in fruits, vegetables, grains, and other plant-based foods, influence various human physiological processes upon ingestion. Their potential role as nutraceuticals has attracted significant interest due to their beneficial properties, particularly in managing metabolic syndrome, inflammatory responses, and hormonal regulation.

The types of phytohormones include several classes: *Auxins*, which stimulate growth and root development; *Cytokinins*, known for promoting cell divi-

sion and shoot formation; *Gibberellins*, involved in stem elongation and fruit development; *Abscisic Acid* (ABA), which regulates stress responses; *Ethylene*, a gas influencing ripening and senescence; *Brassinosteroids*, key in cell elongation and vascular differentiation; *Jasmonates*, which play roles in defense responses; and *Salicylic Acid* (SA), involved in systemic acquired resistance (SAR). Each of these compounds is essential to plant physiology but, when consumed in the human diet, they may also exert substantial health effects, from antioxidant properties to hormonal modulation [1–3].

This review aims to explore the potential health benefits of phytohormones in human diets and their impacts on metabolic pathways, examining current research on how these compounds interact with human biochemical processes to influence health and wellbeing.

TYPES OF PHYTOHORMONES AND THEIR MECHANISMS

Auxins

Auxins, a primary class of plant growth hormones, are essential for root and stem elongation and have been shown to influence hormonal activities within human cells [4, 5]. In research involving dietary intake, auxins are believed to enhance nutrient absorption due to their interaction with human cellular mechanisms, possibly affecting lipid metabolism. Moreover, studies propose that auxins may exert antioxidant effects by directly scavenging free radicals, thereby reducing oxidative stress and consequently mitigating inflammation and promoting cellular health.

Cytokinins

Cytokinins, which are notable for their role in promoting cell division in plants, have shown promise in therapeutic contexts for humans. Some studies highlight cytokinins as antiaging agents due to their potential to combat oxidative stress. Furthermore, cytokinins have been shown to influence cellular signaling pathways that impact immune response and cellular repair processes, thus contributing to improved skin health and potential cancer prevention.

Gibberellins

Gibberellins play a significant role in plant growth, especially in fruit development and seed germination, and have been noted for their effects on human metabolic functions [6]. Gibberellin-like compounds in fruits and vegetables may aid in reducing the risk of obesity and metabolic syndrome through their role in carbohydrate metabolism. Some studies propose that gibberellins could enhance insulin sensitivity and modulate glucose uptake, thus aiding in glycemic control.

Abscisic Acid (ABA)

ABA, commonly found in fruits like grapes and berries, is a stress-response hormone in plants. It has demonstrated significant roles in human health, particularly in managing blood glucose levels and reducing inflammation [7]. Research has shown that ABA acts as an anti-diabetic agent by enhancing glucose uptake and insulin secretion, thus improving metabolic functions and supporting weight management.

Ethylene

Ethylene is a gaseous hormone involved in fruit ripening and is also known to influence the postharvest life of fruits and vegetables. When consumed, ethylene-rich fruits like bananas and tomatoes may provide benefits, such as improved digestion and gut health. Ethylene can potentially affect the human gut microbiome by fostering beneficial bacteria, thus improving metabolic processes and nutrient absorption [8].

Brassino-Steroids

Brassinosteroids are involved in plant cell elongation and stress tolerance and may help in boosting human immune response due to their antioxidant activity. Some studies have also linked brassinosteroids to reduced cholesterol levels, suggesting that they may play a role in cardiovascular health [9].

They are also seen as potential agents against cancer due to their ability to inhibit tumor growth and proliferation in preliminary studies.

Jasmonates

Jasmonates, produced in response to plant stress, are known to interact with stress-signaling pathways in humans. These compounds may help reduce oxidative stress and inflammation, supporting immune functions and acting as anti-inflammatory agents. Some studies suggest that jasmonates may aid in promoting mental well-being by influencing stress-related hormones, possibly offering therapeutic benefits for mental health.

Salicylic Acid (SA)

SA is recognized for its role in plant immunity, and in humans, it has known effects similar to aspirin, providing anti-inflammatory and pain-relieving properties. Dietary intake of SA through fruits like blueberries and tomatoes is associated with reduced risks of chronic diseases, such as heart disease and cancer. SAM's modulation of inflammatory pathways is believed to reduce oxidative stress and promote overall cellular health, making it a valuable compound for enhancing human metabolism and wellbeing.

HUMAN EXPOSURE AND HEALTH IMPACTS OF PHYTOHORMONES

Human exposure to phytohormones primarily comes from diets rich in plant-based foods, including fruits, vegetables, grains, and legumes. For instance, the ingestion of phytoestrogens like isoflavones found in soy products has been linked to positive hormonal effects in humans, such as reduced menopausal symptoms and decreased cancer risk. These compounds are extensively metabolized in the human body, affecting various metabolic processes and offering protection against oxidative stress, a major contributor to aging and degenerative diseases.

Impact on Metabolism and Weight Management

Phytohormones can impact human metabolism significantly by influencing metabolic pathways involved in lipid and glucose metabolism. ABA and gibberellins, for example, enhance insulin sensitivity, potentially lowering blood sugar levels and improving lipid profiles, which are crucial in managing metabolic syndrome and obesity. Additionally, cytokinins have shown anti-obesity properties by modulating fat accumulation and reducing oxidative stress in adipose tissue.

Hormonal Balance and Cancer Prevention

Phytoestrogens, such as those found in soy and flaxseed, mimic estrogen and can modulate estrogenic activity in the human body [10]. These compounds have been associated with a reduced risk of breast and prostate cancers due to their ability to bind to estrogen receptors and reduce the impact of human estrogen, which is linked to cancer risk in hormone-sensitive tissues. Studies have also highlighted that these compounds help regulate hormonal balance and reduce menopause symptoms, contributing to improved quality of life for middle-aged individuals.

Antioxidant and Anti-inflammatory Properties

One of the most crucial impacts of phytohormones on human health is their antioxidant and anti-inflammatory properties. Compounds, such as cytokinins and jasmonates reduce oxidative stress and inflammation by scavenging free radicals, potentially reducing the risk of chronic diseases. This is particularly relevant for the prevention of cardiovascular diseases and neurodegenerative disorders, where oxidative stress is a significant contributing factor.

Immune Function and Mental Health

Emerging research suggests that phytohormones, such as jasmonates and brassinosteroids play roles in enhancing immune function by modulating immune cell activities. They may also reduce stress-related hormonal fluctuations, thus promoting mental well-being. The interaction of these hor-

mones with the human immune system suggests potential applications in stress-related therapies, offering a natural approach to mental health management.

Phytohormones in the human diet, sourced from diverse plant foods, are increasingly recognized for their therapeutic potential in modulating metabolic and physiological processes. With properties that range from antioxidant and anti-inflammatory to immune-enhancing and hormonal-regulating, phytohormones represent promising nutraceutical agents for promoting human health. Continued research into the bioavailability, mechanisms, and long-term effects of these compounds will be vital to understanding their full impact on human metabolism and wellbeing, potentially unlocking new avenues for dietary and therapeutic applications.

TYPES OF PHYTOHORMONES AND THEIR MECHANISMS OF ACTION

Phytohormones, or plant hormones, are organic substances produced by plants that significantly influence physiological processes and developmental stages. Unlike animals, plants lack a nervous system, making phytohormones pivotal for coordinating growth, metabolism, and responses to environmental cues. Remarkably, recent research has also revealed that these phytohormones can influence human health, making them an intriguing area of study. This section discusses seven major classes of phytohormones – auxins, cytokinin, gibberellins, ABA, ethylene, brassinosteroids, jasmines, and salicylic acid – and explores their mechanisms in plants and potential effects in humans.

Auxins

Role in Plant Cell Growth and Division

Auxins are one of the primary plant growth regulators, with indole-3-acetic acid (IAA) as the most common naturally occurring auxin. They primarily stimulate cell elongation, differentiation, and division, playing a crucial role in phototropism, gravitropism, and apical dominance. Auxins interact with receptors like TIR1, initiating signaling pathways that lead to the activation of genes controlling growth-related processes. When cells sense auxins, they undergo elongation through cell wall loosening, facilitated by the acidification of the cell wall due to auxin-induced proton pumping, allowing the cell to expand.

Interaction with Human Estrogen Receptors and Potential Impacts on Hormonal Balance

Auxins, particularly IAA, have been found to interact with human estrogen receptors, suggesting their ability to affect human hormonal balance. Due to structural similarities, certain auxins can bind to estrogen receptors, potentially influencing estrogenic activities. Studies have revealed auxins' possible agonistic effects on estrogen receptors, which may impact hormonal health. However, the exact implications of these interactions are yet to be fully understood and need more in-depth investigation to clarify any potential health risks.

Cytokinins

Cell Division and Differentiation

Cytokinins promote cell division and are essential in maintaining tissue and organ structure by influencing cell differentiation. They act as key regulators in various plant developmental processes, such as shoot formation and leaf senescence. Cytokinins regulate cell division by modulating cyclin-dependent kinase activity, thus promoting cell proliferation in growing tissues, which leads to organ development. In plants, cytokinins maintain a balance between root and shoot growth, and an optimal cytokinin concentration is crucial for regular growth.

Antiaging Effects and Reduction in Oxidative Stress in Humans

Interestingly, cytokinins also exhibit antiaging properties in human cells due to their antioxidant capacity, which mitigates oxidative stress. In vitro studies have shown that cytokinins like kinetin reduce oxidative damage, delay cell senescence, and improve cellular functions. By counteracting oxidative stress, cytokinins can play a preventive role in age-related diseases, although further clinical trials are required to validate their efficacy in humans.

Gibberellins

Seed Germination and Plant Growth Functions

Gibberellins are pivotal in promoting seed germination, stem elongation, and overall plant growth. These hormones break seed dormancy and stimulate the production of enzymes that aid in mobilizing nutrients for seedling development. Gibberellins interact with receptors like GID1, initiating a cascade that degrades DELLA proteins, which are growth repressors, ultimately promoting growth processes.

Possible Pro-Growth Factors for Human Cells

Emerging research indicates that gibberellins may influence human cells as well, particularly in promoting cell proliferation. Gibberellins have demonstrated proliferative effects in vitro, enhancing cellular processes relevant to wound healing and tissue repair. Although these effects are promising, more clinical research is needed to confirm the therapeutic potential of gibberellins for human health applications.

Abscisic Acid (ABA)

Plant Stress Response and Glucose Metabolism in Humans

ABA is a crucial plant hormone involved in managing stress responses, especially during drought conditions, by regulating stomatal closure to prevent water loss. ABA plays a central role in signaling pathways that activate stress-responsive genes, helping plants survive adverse environmental conditions.

Potential Benefits for Insulin Sensitivity and Metabolic Syndrome

In humans, ABA has been shown to play a role in glucose metabolism and insulin sensitivity, offering potential benefits in managing metabolic syndrome. Studies indicate that ABA can enhance insulin sensitivity by activating peroxisome proliferator-activated receptor gamma (PPARγ), a regulator of glucose and lipid metabolism. Consequently, ABA holds promise as a supplement to help manage blood glucose levels, though more research is required to substantiate these effects.

Ethylene

Role in Fruit Ripening and Stress Response in Plants

Ethylene is a gaseous hormone responsible for regulating fruit ripening, leaf senescence, and stress responses in plants. The hormone's involvement in fruit ripening has significant implications in agriculture, where controlling ethylene levels can extend shelf life and maintain product quality. Ethylene also modulates defense mechanisms, helping plants respond to various environmental stresses.

Limited Human Metabolic Effects but Enhances Nutrient Content in Food

While ethylene itself has limited metabolic effects in humans, its role in enhancing food quality by influencing ripening is beneficial for nutrient content and flavor. Ethylene-treated fruits are often richer in bioactive compounds like vitamins and antioxidants, which contribute positively to human nutrition. This makes ethylene crucial in food technology for enhancing the quality and health benefits of plant-derived foods.

Brassinosteroids

Cell Differentiation and Growth

Brassinosteroids are essential growth-promoting hormones in plants that regulate cell elongation, division, and differentiation. They work by binding to BRI1 receptors, triggering signaling pathways that modulate gene expression involved in growth and development. Brassinosteroids play vital roles in enhancing photosynthetic efficiency, making them valuable for agricultural applications.

Anticancer Properties and Impact on Lipid and Glucose Metabolism

Brassinosteroids exhibit promising anticancer properties by inducing apoptosis in cancerous cells, making them potential candidates for cancer treatment. Studies have found that certain brassinoster-

oids inhibit cell proliferation in various cancer cell lines. Additionally, brassinosteroids affect lipid and glucose metabolism, potentially benefiting individuals with metabolic disorders. However, further clinical trials are necessary to assess their therapeutic applications in humans.

Jasmonates

Defense Mechanisms in Plants

Jasmonates, including jasmonic acid, play critical roles in plant defense by regulating responses to herbivores and pathogens. They initiate signaling pathways that activate genes associated with protective compounds, thereby enhancing plant resilience. Jasmonates also modulate growth and reproductive processes, contributing to plant survival and adaptation.

Anti-Inflammatory and Anticancer Effects in Humans

Jasmonates have gained attention in medical research for their anti-inflammatory and anticancer properties. Studies have shown that methyl jasmonate induces apoptosis in cancer cells, suggesting potential therapeutic applications. Furthermore, jasmonates exhibit anti-inflammatory effects, which may help in managing conditions like arthritis. While promising, clinical validation is needed to confirm these effects and establish jasmonates as a viable treatment option.

Salicylic Acid

Plant Immunity

Salicylic acid is a critical hormone in plant immunity, responsible for activating defense mechanisms against pathogens. By inducing SAR, salicylic acid strengthens plant defenses, enhancing resistance to diseases. The hormone regulates the expression of pathogenesis-related proteins that deter pathogen attacks, ensuring plant health and productivity.

Role in Human Cardiovascular Health

Salicylic acid and its derivative, aspirin, have been widely studied for their cardiovascular benefits in humans, particularly in preventing blood clot formation and reducing the risk of heart attacks. Aspirin's anti-inflammatory and antiplatelet effects are well-documented, making it a valuable drug for cardiovascular protection. Furthermore, regular low-dose aspirin is recommended for certain individuals to reduce the risk of cardiovascular events.

In conclusion, phytohormones play diverse and essential roles in plant development, growth, and defense mechanisms. Additionally, many phytohormones exhibit promising health benefits for humans, ranging from antiaging and anti-inflammatory effects to potential therapeutic applications in cancer treatment. While more research is still needed to understand the full scope of these effects, phytohormones represent a unique intersection of plant biology and human health, offering potential insights for therapeutic applications.

IMPACT ON HUMAN METABOLISM AND HEALTH

Research into phytohormones – the chemical messengers integral to plant development – has revealed that these compounds may also influence human health. Their effects span multiple metabolic pathways, particularly in areas, such as inflammation, oxidative stress, glucose regulation, and cancer prevention. Key phytohormones, such as ABA, jasmonates, salicylic acid, cytokinins, and brassinosteroids have shown promise for their anti-inflammatory, antioxidant, anticancer, and cardiovascular benefits.

Anti-Inflammatory Effects [10–14]

Role of ABA, Jasmonates, and Salicylic Acid in Reducing Chronic Inflammation

Inflammation is a critical response by the immune system to injury or infection, but chronic inflammation is linked to several diseases, including arthritis, cardiovascular disease, and some cancers. ABA, jasmonates, and salicylic acid have shown potential in reducing inflammation in human cells

through various mechanisms.

1. *ABA:* ABA contributes to anti-inflammatory responses by modulating immune cell activity and reducing pro-inflammatory cytokine production. ABA has been shown to activate peroxisome PPARγ, a receptor involved in glucose and lipid metabolism, which also plays a role in inflammation reduction. By targeting PPARγ, ABA can help reduce inflammation in diseases like arthritis and potentially lower the risks associated with metabolic syndrome.
2. *Jasmonates:* These phytohormones, particularly methyl jasmonate, have demonstrated anti-inflammatory effects in various studies. Jasmonates inhibit nuclear factor kappa B (NF-κB) signaling, which is a major pathway responsible for inflammation in the body. By downregulating NF-κB, jasmonates help limit chronic inflammation, thereby reducing the likelihood of inflammation-driven diseases.
3. *Salicylic Acid:* As a derivative of the salicylates, salicylic acid plays an essential role in reducing inflammation by inhibiting cyclooxygenase (COX) enzymes, particularly COX-2, which mediates inflammatory responses. In humans, this effect has long been recognized through the use of aspirin, a derivative of salicylic acid, in reducing pain, fever, and inflammation. Salicylic acid's anti-inflammatory properties are essential in managing chronic inflammation in conditions, such as cardiovascular diseases and arthritis.

Antioxidant Activity

Cytokinins and Brassinosteroids in Free Radical Neutralization and Oxidative Stress Reduction

Oxidative stress occurs when there is an imbalance between free radicals and antioxidants in the body, leading to cellular damage. Antioxidants neutralize these free radicals, preventing cellular aging, and reducing the risk of chronic diseases. Both cytokinins and brassinosteroids have been studied for their potent antioxidant properties.

1. *Cytokinins:* Cytokinins, particularly kinetin, are known for their ability to scavenge free radicals and reduce oxidative stress. Cytokinins have been shown to protect DNA from oxidative damage, thereby reducing the risk of mutations that could lead to cancer or degenerative diseases. Their ability to promote cell longevity has implications for antiaging and disease prevention, particularly in tissues vulnerable to oxidative stress [15, 16].
2. *Brassinosteroids:* Brassinosteroids exhibit strong antioxidant effects, which help in reducing oxidative damage in cells. Research shows that these phytohormones can enhance the activity of antioxidant enzymes, including superoxide dismutase and catalase, which protect cells from oxidative stress. Brassinolide's antioxidative functions suggest they could be valuable in mitigating oxidative stress-associated conditions like cardiovascular disease and neurodegeneration.

Regulation of Glucose Metabolism

ABA's Influence on Insulin Sensitivity and Glucose Regulation

ABA is involved in plant stress responses, but studies indicate it can also influence glucose metabolism in humans. ABA activates PPARγ, a receptor that regulates insulin sensitivity and glucose metabolism [17–19]. By improving insulin sensitivity, ABA can play a role in managing conditions like diabetes and metabolic syndrome, which are characterized by insulin resistance and high blood sugar levels.

Research has shown that ABA supplementation improves glucose uptake in muscle cells, which is critical for managing blood glucose levels. Furthermore, ABA's influence on adipose tissue enhances insulin sensitivity, further supporting its potential as a natural agent for blood glucose regulation in diabetic individuals.

Anticancer Properties [20–24]

Apoptotic and Anti-Proliferative Effects of Brassinosteroids and Jasmonates on Cancer Cells

The anticancer properties of phytohormones, especially brassinosteroids and jasmonates, have garnered significant attention. Both hormones demonstrate promising effects in inducing apoptosis and

inhibiting proliferation in cancer cells.

1. *Brassino-steroids:* These plant hormones have shown the ability to induce apoptosis in various cancer cell lines. Brassinosteroids work by modulating the expression of genes involved in cell death and inhibiting cancer cell proliferation. Studies have suggested that brassinosteroids could be developed as adjunct therapies in cancer treatment, especially given their minimal toxicity to normal cells.
2. *Jasmonates:* Jasmonates, particularly methyl jasmonate, have potent anticancer properties. They work by disrupting mitochondrial function in cancer cells, leading to the release of cytochrome c, which initiates the apoptosis pathway. Additionally, jasmonates can inhibit cell cycle progression, making them promising candidates for anticancer therapies in various types of cancer.

Cardiovascular Health

Salicylic Acid's Anti-Inflammatory Properties and Cytokinins' Role in Vascular Health [25–28]

The cardiovascular benefits of salicylic acid and cytokinins highlight the potential of phytohormones in managing heart health and preventing vascular diseases.

1. *Salicylic Acid:* Salicylic acid's anti-inflammatory properties make it an essential compound for cardiovascular health, particularly in reducing the risk of atherosclerosis and blood clots. Aspirin, a derivative of salicylic acid, is widely used to prevent heart attacks and strokes by inhibiting platelet aggregation and preventing blood clots.
2. *Cytokinins:* Cytokinins, particularly kinetin, contribute to vascular health by improving endothelial function and reducing oxidative stress. Studies suggest that cytokinins can help reduce the formation of plaques in blood vessels, potentially lowering the risk of conditions like atherosclerosis.

POTENTIAL THERAPEUTIC APPLICATIONS OF PHYTOHORMONES

The unique properties of phytohormones hold promising therapeutic applications across various health areas, including cancer prevention, diabetes management, cardiovascular health, bone health, and detoxification. Research suggests that these plant-derived compounds could provide complementary treatments for numerous conditions.

Cancer Prevention

Brassinosteroids and Jasmonates as Complementary Cancer Therapies

Both brassinosteroids and jasmonates exhibit anticancer properties that make them potential candidates for complementary cancer therapies. Brassinosteroids induce apoptosis and inhibit the proliferation of cancer cells without affecting normal cells, suggesting a targeted therapeutic potential [28, 29]. Additionally, jasmonates have been shown to interfere with cancer cell metabolism, further inhibiting tumor growth.

These phytohormones could be developed as adjunctive therapies to conventional treatments, potentially enhancing treatment efficacy and reducing adverse effects.

Diabetes Management

ABA as a Natural Agent for Glucose Regulation in Diabetes and Metabolic Syndrome

ABA has shown considerable promise as a natural agent for managing blood glucose levels, particularly in individuals with diabetes and metabolic syndrome. By enhancing insulin sensitivity and improving glucose uptake, ABA can play a preventive role in diabetes management [30–34]. This makes ABA an appealing therapeutic option for those seeking natural alternatives to pharmaceutical interventions.

Cardiovascular Health

Salicylic Acid and Cytokinins for Inflammation and Vascular Support

The anti-inflammatory properties of salicylic acid, particularly as seen in aspirin, are well-established for preventing cardiovascular events. Salicylic acid's effects on platelet aggregation re-

duce the risk of heart attacks and strokes. Furthermore, cytokinins' role in reducing oxidative stress and improving vascular health makes them beneficial in maintaining cardiovascular health.

Bone Health

Cytokinins and Brassinosteroids for Bone Density and Osteoporosis Prevention

Phytohormones like cytokinins and brassinosteroids show promise in supporting bone health. Cytokinins may help maintain bone density by reducing oxidative stress, which is linked to bone degradation in osteoporosis [35–37]. Brassinosteroids also play a role in enhancing bone formation, making them potential candidates for osteoporosis prevention.

Detoxification

Role of Antioxidants in Supporting Cellular Detoxification

The antioxidant properties of phytohormones support cellular detoxification by neutralizing harmful free radicals and preventing cellular damage. By enhancing antioxidant enzyme activity, cytokinins and brassinosteroids help cells counteract the toxic effects of pollutants and other environmental stressors, promoting overall cellular health.

CHALLENGES AND CONSIDERATIONS

While phytohormones hold significant potential for human health, several challenges must be addressed to translate these findings into therapeutic applications. Issues of bioavailability, dosage, and research limitations present barriers to the effective use of phytohormones.

Bioavailability and Efficacy: Absorption of Phytohormones in Humans

One of the primary challenges in utilizing phytohormones is their bioavailability in the human body. Many phytohormones, such as ABA and jasmonates, may have low bioavailability when ingested, meaning they are not easily absorbed or utilized by the body [38–40]. Enhancing the absorption of phytohormones could involve developing novel delivery methods or using nanoformulations that improve their stability and efficacy.

Dosage and Safety: Effective and Safe Doses for Therapeutic Use

Establishing safe and effective dosages for phytohormones is critical to avoid potential side effects. Although phytohormones are generally considered safe, improper dosing can lead to adverse effects. For instance, while ABA and jasmonates are non-toxic at low levels, high doses could potentially disrupt hormonal balance or interfere with metabolic processes. Clinical trials are necessary to determine optimal dosages for therapeutic use.

Research Limitations: Need for More Human Studies and Clinical Trials

Most of the current evidence supporting the health benefits of phytohormones is based on in vitro or animal studies, with limited data from human trials. Clinical studies are essential to confirm these findings and establish reliable therapeutic applications. Without such data, the translation of phytohormones from experimental compounds to effective clinical therapies remains challenging (Patrono et al., 2005).

CONCLUSIONS

Research into phytohormones highlights their potential in promoting human metabolic health and overall well-being. These plant-derived compounds – such as ABA, jasmonates, salicylic acid, cytokinins, and brassinosteroids offer a wide array of health benefits. For instance, ABA enhances glucose regulation and insulin sensitivity, making it a promising agent for diabetes Abscisic acid (ABA) has been implicated in the enhancement of glucose regulation and insulin sensitivity, making it a promising candidate for the management of diabetes. Jasmonates and brassinosteroids have exhibited notable anticancer properties, characterized by the induction of apoptosis and inhibition of proliferation in cancerous cells.

Additionally, salicylic acid is known for its cardiovascular benefits, notably in reducing inflammation and preventing platelet aggregation, thereby supporting heart health. Cytokinins and brassinosteroids also have strong antioxidant properties, helping to neutralize free radicals, reduce oxidative stress, and promote cellular health, which is essential for longevity and prevention of degenerative diseases. Each phytohormone's unique biochemical functions extend benefits beyond plant development to human health, showing promise as natural agents for managing chronic diseases and supporting overall well-being. Subsequent investigations should be directed towards a more comprehensive understanding of the bioavailability, efficacy, and safety profiles of phytohormones in human contexts. Given that many phytohormones are not easily absorbed when ingested, enhancing delivery through nano-formulations and bioavailability-enhancing techniques could make them more effective therapeutically. Additionally, research into the optimal dosages and safety of phytohormones, particularly for chronic use in conditions, such as diabetes, cardiovascular disease, and cancer, is necessary. Understanding their interactions with other nutrients and medications may also lead to new integrated health therapies. Exploring phytohormones in the context of nutrition is another promising avenue. The strategic incorporation of these compounds into functional foods or dietary supplements could revolutionize preventative healthcare, merging plant science with dietary and medical practices to empower personalized health approaches.. Their diverse roles—spanning anti-inflammatory, antioxidant, glucose-regulatory, and anticancer effects—position them as natural alternatives to synthetic drugs, aligning with the trend toward holistic health care. With continued research and development, phytohormones may become essential components in future therapeutic strategies, dietary interventions, and supplements, supporting a balanced and resilient human body. In summary, phytohormones hold vast potential as natural health solutions. The successful translation of plant compounds into human therapeutic agents represents a significant milestone, underscoring the immense potential of continued research and collaborative efforts to shape the future of sustainable and integrated healthcare.

REFERENCES

1. Abeles FB, Morgan PW, Saltveit ME. Ethylene in plant biology. Academic Press; 1992.
2. Arif Y, Sami F, Siddiqui H, Bajguz A, Hayat S. Salicylic acid in relation to other phytohormones in plant: A study towards physiology and signal transduction under challenging environment. Environ Exp Bot. 2020;123(1):112–125. doi: 10.1016/j.envexpbot.2020.104040.
3. Bajguz A, Hayat S. Effects of brassinosteroids on the plant responses to environmental stresses. Plant Physiology and Biochemistry. 2009;47(1):1–8.
4. Bajguz A, Hayat S. Effects of brassinosteroids on the plant responses to environmental stresses. Plant Physiol Biochem. 2009;47(1):1–8. doi: 10.1016/j.plaphy.2008.10.002.
5. Bassaganya-Riera, J, et al. Mechanisms of action and potential health benefits of abscisic acid in humans. Nutrition Reviews. 2011;69(2):135–145.
6. Bassaganya-Riera J, Skoneczka JA, Kingston DGI, Krishnan A, Misyak S, Guri AJ, et al. Mechanisms of action and potential health benefits of abscisic acid in humans. Nutr Rev. 2011;69(2):135–145.
7. Bleecker AB, Kende H. Ethylene: a gaseous signal molecule in plants. Annu Rev Cell Dev Biol. 2000:16:1–18. doi: 10.1146/annurev.cellbio.16.1.1.
8. Cassidy A, Hanley B. Isoflavones, lignans, and stilbenes–origins, metabolism, and potential importance to human health. J Sci Food Agric. 2000;80(7):1044–1059. doi: 10.1002/(SICI)1097-0010(20000515)80:7<1044::AID-JSFA586>3.0.CO;2-N.
9. Clouse SD, Sasse JM. Brassinosteroids: essential regulators of plant growth and development. Annu Rev Plant Physiol Plant Mol Biol. 1998:49:427–451. doi: 10.1146/annurev.arplant.49.1.427.
10. Cutler SR, et al. Abscisic acid: emergence of a core signaling network. Annual Review of Plant Biology. 2010;61:651–679.
11. Cutler SR, Rodriguez PL, Finkelstein RR, Abrams SR. Abscisic acid: emergence of a core signaling network. Annu Rev Plant Biol. 2010:61:651–679. doi: 10.1146/annurev-arplant-042809-112122.

12. Davies PJ. (Ed.). Plant Hormones: Biosynthesis, Signal Transduction, Action! Springer; 2010.
13. Draelos ZD. Antioxidant-based dermatologic formulations. Clin Dermatol. 2010;27(5):501–506.
14. Duursen MBM. Modulation of estrogen synthesis and metabolism by phytoestrogens in vitro and the implications for women's health. Toxicol Res (Camb). 2017;6(6):772–794. doi: 10.1039/c7tx00184c.
15. Fathy M, Saad Eldin SM, Naseem M, Dandekar T. Cytokinins: Wide-spread signaling hormones from plants to humans with high medical potential. Nutrients. 2022;14(7):1495. doi: 10.3390/nu14071495.
16. Flescher E. Jasmonates in cancer therapy. Cancer Letters. 2007;245(1–2):1–10.
17. Flescher E. Jasmonates in cancer therapy. Cancer Lett. 2007;245(1-2):1–10. doi: 10.1016/j.canlet.2006.03.001.
18. Guri AJ, et al. Abscisic acid and the activation of PPAR gamma as potential therapy in metabolic syndrome. Journal of Nutrition and Biochemistry. 2007;18(11):853–859.
19. Harberd NP, Belfield E, Yasumura Y. The angiosperm gibberellin-GID1-DELLA growth regulatory mechanism: How an "inhibitor of an inhibitor" enables flexible response to fluctuating environments. Plant Cell. 2009;21(5):1328–1339. doi: 10.1105/tpc.109.066969.
20. Howe GA, Jander G. Plant immunity to insect herbivores. Annu Rev Plant Biol. 2008:59:41–66. doi: 10.1146/annurev.arplant.59.032607.092825.
21. Kieber JJ, Schaller GE. Cytokinin signaling in plant development. Development. 2018;145(4):dev149344. doi: 10.1242/dev.149344.
22. Krishna, P. Brassinosteroid-mediated stress responses. J Plant Growth Regul. 2003;22(4):289–297. doi: 10.1007/s00344-003-0058-z.
23. Krishna, P. Brassinosteroid-mediated stress responses. Journal of Plant Growth Regulation. 2003;22(4):289–297.
24. Leyser O. Auxin signaling. Plant Physiol. 2018;176(1):465–479. doi: 10.1104/pp.17.00765.
25. Magnone M, Ameri P, Salis A, Andraghetti G, Emionite L, Murialdo G, et al. Abscisic acid: A new player in the pathophysiology of insulin resistance? J Diabetes Res. 2015;2015:1–9.
26. Magnone, M., et al. Abscisic acid: A new player in the pathophysiology of insulin resistance? Journal of Diabetes Research. 2015:1–9.
27. Medzhitov R. Origin and physiological roles of inflammation. Nature. 2008;454(7203):428–435. doi: 10.1038/nature07201.
28. Mok MC, Mok DW. Cytokinin metabolism and action. Annu Rev Plant Physiol Plant Mol Biol. 2001:52:89–118. doi: 10.1146/annurev.arplant.52.1.89.
29. Patrono C., et al. Low-dose aspirin for the prevention of atherothrombosis. New England Journal of Medicine. 2005;353(22):2373–2383.
30. Patrono C, García Rodríguez LA, Landolfi R, Baigent C. Low-dose aspirin for the prevention of atherothrombosis. N Engl J Med. 2005;353(22):2373–2383. doi: 10.1056/NEJMra052717.
31. Rattan SI, Sodagam L. Gerontomodulatory and youth-preserving effects of kinetin. Ann N Y Acad Sci. 2005;1057(1):470–479.
32. Sakakibara H. Cytokinins: Activity, biosynthesis, and translocation. Annu Rev Plant Biol. 2006:57:431–449. doi: 10.1146/annurev.arplant.57.032905.105231.
33. Saltveit ME. Effect of ethylene on quality of fresh fruits and vegetables. Postharvest Biol Technol. 1993;15(3):279–292. doi: 10.1016/S0925-5214(98)00091-X.
34. Vanneste S, Friml J. Auxin: A trigger for change in plant development. Cell. 2009;136(6):1005–1016. doi: 10.1016/j.cell.2009.03.001.
35. Yang B, Dong Y, Yang F, Zhang Y. Nanoformulations to enhance the bioavailability and physiological functions of polyphenols. Molecules. 2020;25(20):4613. doi: 10.3390/molecules25204613.
36. Wasternack C, Hause B. Jasmonates: Biosynthesis, perception, signal transduction, and action in plant stress response, growth, and development. An Update to the 2007 Review in Annals of Botany. Ann Bot. 2013;111(6):1021–1058. doi: 10.1093/aob/mct067.
37. Woodward AW, Bartel B. Auxin: Regulation, action, and interaction. Ann Bot. 2005;95(5):707–735. doi: 10.1093/aob/mci083.

38. Yamaguchi S. Gibberellin metabolism and its regulation. Annu Rev Plant Biol. 2008:59:225-251. doi: 10.1146/annurev.arplant.59.032607.092804.
39. Zhu JY, Sae-Seaw J, Wang ZY. Brassinosteroid signalling. Development. 2013;140(8):1615-1620. doi: 10.1242/dev.060590.
40. Kim JY, Park Y, Lee SH, Park EJ, Lee HJ. Comparative study on estrogen receptor alpha dimerization and transcriptional activity of parabens. Toxicol Res. 2024;40(1):153–161. doi: 10.1007/s43188-023-00212-1.

