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Review Article

PLANT-BASED COLOR THERAPY: A NATURAL APPROACH TO RHEUMATOID ARTHRITIS TREATMENT

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ABSTRACT

Rheumatoid arthritis (RA) is a chronic autoimmune disorder characterized by persistent joint inflammation, pain, and progressive cartilage degradation. Conventional treatments, including nonsteroidal anti-inflammatory drugs and biologics, provide symptomatic relief but are often associated with adverse effects. Plant-based color therapy has emerged as a promising complementary approach to managing RA. This therapy is based on the therapeutic potential of naturally occurring plant pigments, such as flavonoids, carotenoids, anthocyanins, and chlorophyll, which exhibit strong anti-inflammatory, antioxidant, and immunomodulatory properties. This review explores the scientific basis of plant-derived pigments in mitigating RA symptoms through their biochemical interactions with inflammatory pathways. Red pigments, rich in anthocyanins and carotenoids, have been shown to suppress pro-inflammatory cytokines and oxidative stress. Yellow and orange pigments, particularly curcumin and beta-carotene, modulate immune responses and reduce joint inflammation. Green pigments, such as chlorophyll and polyphenols, contribute to detoxification and immune regulation. Blue and purple pigments, primarily anthocyanins, enhance collagen stability and reduce oxidative damage in joint tissues. White and brown pigments, found in garlic, onions, and whole grains, offer additional anti-inflammatory benefits by modulating gut microbiota and reducing systemic inflammation. A synergistic, multi-color dietary approach may provide greater therapeutic benefits in RA management than single-compound interventions. However, the clinical application of plant-based color therapy remains underexplored, necessitating further research to establish standardized dosages and long-term efficacy. By integrating plant-based color therapy with conventional treatments, a holistic and sustainable approach to RA management can be achieved. This review highlights the potential of plant pigments as a natural, non-toxic alternative for alleviating RA symptoms and emphasizes the need for clinical trials to validate their therapeutic efficacy.

KEYWORDS: Rheumatoid arthritis, plant-based therapy, phytochemicals, antioxidants, inflammation, flavonoids, carotenoids.

1. INTRODUCTION

Rheumatoid arthritis (RA) is a chronic autoimmune disorder characterized by persistent inflammation of the synovial joints, leading to pain, stiffness, and progressive joint damage. Affecting millions worldwide, RA significantly diminishes quality of life, increases the risk of disability, and imposes a substantial burden on healthcare systems. While the exact etiology of RA remains unclear, genetic predisposition, environmental triggers, and immune system dysregulation play crucial roles in disease progression(Yadav et al., n.d.). Conventional treatments for RA primarily include disease-modifying antirheumatic drugs (DMARDs), biologics, and nonsteroidal anti-inflammatory drugs (NSAIDs). Although these therapies provide symptomatic relief and slow disease progression, they are often associated with adverse effects such as gastrointestinal distress, immunosuppression, and increased susceptibility to infections. Additionally, long-term dependency on pharmacological interventions may not always yield satisfactory outcomes, prompting a growing interest in complementary and alternative therapies(Prasad et al., 2023). One emerging area of interest in RA management is plant-based therapies, which utilize the bioactive compounds found in natural sources to modulate inflammation and oxidative stress. Phytochemicals derived from medicinal plants have demonstrated promising anti-inflammatory, immunomodulatory, and analgesic properties, making

them attractive alternatives or adjuncts to conventional RA treatments. Among these novel approaches, plant-based color therapy has gained attention for its potential to influence physiological and psychological well-being(Ghosh et al., 2024). Color therapy, also known as chronotherapy, is based on the concept that specific colors can stimulate biological responses that promote healing and balance in the body. The pigments responsible for plant colors such as flavonoids, carotenoids, and anthocyanins exhibit potent antioxidant and anti-inflammatory effects. By incorporating color-rich plant sources into dietary and therapeutic strategies, individuals with RA may benefit from enhanced symptom relief and improved disease outcomes(Cajochen, 2024). This review explores the potential role of plant-based color therapy in RA treatment, examining the bioactive properties of plant pigments and their therapeutic implications. By integrating scientific evidence with traditional healing practices, this approach aims to provide a holistic, natural strategy for managing RA while minimizing the risks associated with conventional medications(Josa et al., 2024).

2. UNDERSTANDING RHEUMATOID ARTHRITIS

2.1. Pathophysiology of RA

Rheumatoid arthritis (RA) is a chronic autoimmune disorder that primarily affects the synovial joints, leading to persistent inflammation, joint destruction, and disability. The disease develops due to a complex interplay of genetic predisposition, environmental triggers, and immune system dysfunction. Individuals carrying specific genetic markers, such as HLA-DR4 and HLA-DR1 alleles, are more susceptible to RA, while factors like smoking, microbial infections, and gut dysbiosis can contribute to disease onset(Shrivastava & Pandey, 2013).The immune system plays a central role in RA pathogenesis, where an abnormal immune response mistakenly targets healthy synovial tissue. This process begins with the activation of antigen-presenting cells, which stimulate autoreactive CD4+ T-helper cells, particularly Th1 and Th17 cells. These immune cells release pro-inflammatory cytokines, including tumor necrosis factor-alpha (TNF-α), interleukin-1 (IL-1), and interleukin-6 (IL-6), which drive inflammation, synovial hyperplasia, and joint damage(Ding et al., 2023). Persistent inflammation leads to the thickening of the synovial membrane, a process known as synovial hyperplasia. Fibroblast-like synoviocytes (FLS) proliferate and secrete inflammatory mediators, further amplifying joint damage. The formation of pannus, an aggressive inflammatory tissue, invades cartilage and bone, contributing to erosion and deformity. Additionally, immune system dysregulation promotes the activation of osteoclasts bone-resorbing cells stimulated by receptor activator of nuclear factor Kappa-B ligand (RANKL). This results in progressive bone erosion, reduced joint function, and chronic pain(Sanchez-Lopez et al., 2022). RA is not confined to joint pathology; it also has systemic implications. Chronic inflammation can contribute to cardiovascular disease, pulmonary complications, osteoporosis, and an increased risk of infections due to immune system dysfunction. Patients with RA often experience severe fatigue, depression, and reduced quality of life, further complicating disease management(Wu et al., 2022). Oxidative stress is another crucial factor in RA pathogenesis. Excessive production of reactive oxygen species (ROS) contributes to DNA damage, lipid peroxidation, and mitochondrial dysfunction, exacerbating inflammation and joint deterioration. Antioxidants derived from plant-based sources have shown potential in counteracting oxidative stress, making them a promising therapeutic approach for RA. Given the complexity of RA and the limitations of conventional treatments, alternative strategies such as plant-based color therapy are gaining attention. The bioactive compounds present in plant pigments, known for their antioxidant and anti-inflammatory properties, may offer a novel and holistic approach to managing RA by targeting multiple disease mechanisms(Zamudio-Cuevas et al., 2022). Figure number one show the heatmap of therapeutic effect of plant based pigments in rheumatoid arthritis management.

2.2. Role of Oxidative Stress and Inflammation in RA Progression

Oxidative stress and chronic inflammation play a critical role in the pathogenesis and progression of rheumatoid arthritis (RA). Oxidative stress arises when there is an imbalance between the excessive production of reactive oxygen species (ROS) and the body's antioxidant defense mechanisms. In RA, immune cells such as macrophages and neutrophils generate high levels of ROS, leading to oxidative damage in synovial tissues. This damage results in lipid peroxidation, protein modifications, and mitochondrial dysfunction, further amplifying the inflammatory response. ROS also activate nuclear factor kappa B (NF-κB), a key transcription factor that promotes the production of pro-inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-1 beta (IL-1β), and interleukin-6 (IL-6). These cytokines drive synovial inflammation, cartilage degradation, and bone erosion, contributing to disease progression(Kaur et al., 2021). Chronic inflammation in RA is sustained by a complex network of immune cells and inflammatory mediators. The persistent activation of synovial fibroblasts, macrophages, and T-helper cells leads to continuous cytokine release, which recruits additional immune cells to the joint, exacerbating inflammation. This inflammatory cascade enhances the expression of matrix metalloproteinases (MMPs), enzymes responsible for breaking down cartilage and extracellular matrix components. Furthermore, inflammation stimulates osteoclast differentiation through increased expression of receptor activator of nuclear factor Kappa-B ligand (RANKL), leading to progressive bone resorption and joint destruction. The systemic nature of RA-related inflammation is also linked to comorbidities such as cardiovascular disease, metabolic disorders, and neuroinflammation, highlighting the need for effective anti-inflammatory interventions(Weyand & Goronzy,

2021)(Iqbal & Ahmed, n.d.). Table number show the Plant-based color therapy presents a promising complementary approach for managing rheumatoid arthritis.

2.3. Importance of Diet and Natural Compounds in RA Management

Diet and natural compounds have gained significant attention as potential modulators of oxidative stress and inflammation in RA. Various plant-derived bioactive compounds, including flavonoids, carotenoids, polyphenols, and anthocyanins, possess strong antioxidant and anti-inflammatory properties. These compounds help scavenge ROS, inhibit NF-κB activation, and suppress the production of pro-inflammatory cytokines, thereby reducing oxidative damage and inflammation in RA. For instance, curcumin, a polyphenol found in turmeric, has been shown to inhibit TNF-α and IL-6 signaling pathways, leading to reduced joint swelling and pain. Similarly, resveratrol, present in grapes and berries, exhibits immunomodulatory effects by downregulating inflammatory pathways and enhancing antioxidant enzyme activity(Direito et al., 2021). A diet rich in colorful plant-based foods, such as fruits, vegetables, nuts, and whole grains, provides essential micronutrients and phytochemicals that support immune balance and joint health. Omega-3 fatty acids from sources like flaxseeds and chia seeds have been found to suppress the production of pro-inflammatory eicosanoids, contributing to symptom relief in RA. Additionally, dietary interventions such as the Mediterranean diet, which emphasizes plant-based foods, healthy fats, and anti-inflammatory compounds, have been associated with improved RA outcomes(Stephen et al., 2023). The integration of plant-based therapies, particularly those leveraging the therapeutic potential of natural pigments and bioactive compounds, offers a promising strategy for RA management. By reducing oxidative stress and inflammation through dietary modifications, individuals with RA may experience improved joint function, reduced disease progression, and enhanced overall safety. Exploring plant-based color therapy as a complementary approach to conventional RA treatments could provide a holistic and sustainable solution for long-term disease management(Awasthi et al., 2024).

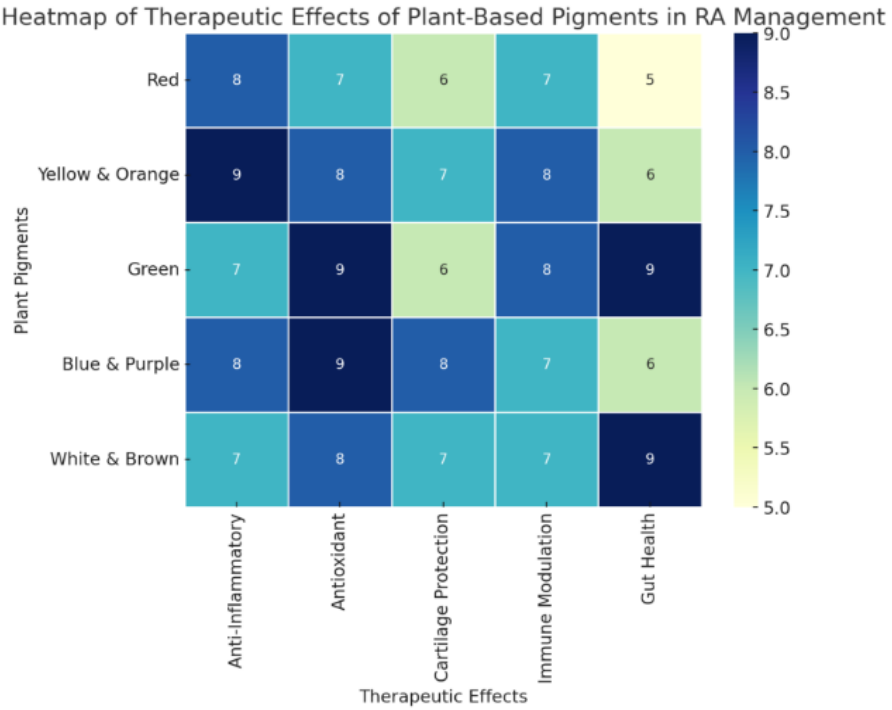

Figure No: 1. Heatmap of therapeutic effect of plant based pigments in rheumatoid arthritis management.

3. THE SCIENCE OF COLOR THERAPY IN MEDICINE

3.1. Historical Background and Principles of Color Therapy

Color therapy, also known as chronotherapy, is an alternative healing practice that has been used for centuries in various cultures to promote physical and emotional well-being. Ancient civilizations, including the Egyptians, Greeks, Chinese, and Indians, believed in the therapeutic potential of colors and used them in medical treatments. In Ayurveda and Traditional Chinese Medicine (TCM), different colors were associated with the balance of energy within the body and were used to restore harmony in individuals suffering from various ailments(Ismaeil & Sobaih, 2022). The fundamental principle of color therapy is based on the idea that different colors have specific vibrational frequencies that can influence the body's energy systems. According to chronotherapy, exposure to certain colors can stimulate physiological responses that promote healing and restore balance. This concept aligns with modern scientific research on the impact of light and

color on biological processes, including circadian rhythms, mood regulation, and cellular function(Valnet, 2022).

3.2. Psychological and Physiological Effects of Colors on Health

Scientific studies have shown that colors can have a profound impact on both psychological and physiological processes. The perception of color is processed in the brain's visual cortex and influences neural pathways associated with mood, stress response, and hormonal regulation. Different colors evoke specific emotional and physiological responses. Red is associated with increased energy, stimulation, and enhanced circulation, promoting blood flow and activating metabolic processes. Blue is known for its calming and cooling effects, often used to reduce stress, lower blood pressure, and promote relaxation. Green symbolizes balance and harmony, commonly linked to healing and regeneration with soothing effects on the nervous system(Awad et al., 2024).

Yellow is connected to mental stimulation, positivity, and enhanced cognitive function, helping to improve focus and alleviate depressive symptoms. Purple or violet is associated with spiritual awareness and tranquility, supporting mental clarity and reducing anxiety. Physiologically, exposure to specific colors influences neurotransmitter and hormone production. Blue light regulates melatonin, essential for sleep-wake cycles, while red light therapy is studied for enhancing mitochondrial function, improving circulation, and supporting tissue repair(Gupta, 2021).

3.3. Application of Color Therapy in Complementary Medicine

Color therapy has been integrated into complementary and holistic medicine as a non-invasive approach to healing. It is often used alongside conventional treatments to support emotional well-being, alleviate pain, and enhance recovery. One key application is light therapy for mood disorders, where blue and white light exposure helps treat seasonal affective disorder (SAD) and other mood-related conditions by regulating circadian rhythms and improving overall mood. Another significant use is pain management and inflammation reduction, with red and near-infrared light therapy showing potential in reducing inflammation, alleviating pain, and promoting tissue healing, particularly for conditions like arthritis, muscle injuries, and neuropathic pain(Gupta, 2021). In holistic practices such as Reiki and Ayurveda, color therapy is employed in chakra healing, where specific colors are believed to balance energy centers in the body and restore health. Additionally, healthcare environments utilize color psychology in hospital designs, with blue and green hues promoting relaxation and reducing patient stress. The emerging scientific understanding of color's effects on health supports its role as a complementary therapy. When integrated with plant-based treatments and lifestyle modifications, color therapy may provide a holistic approach to managing chronic conditions like rheumatoid arthritis by addressing both physiological and emotional aspects of the disease(La Forge, 2024)(Iqbal, Altaf, Basit, et al., 2024).

Table No: 1. Plant-based color therapy presents a promising complementary approach for managing rheumatoid arthritis.

Color	Key Phytochemicals	Sources	Mechanism of Action	Benefits for RA	References/ Evidence	References
Red	Anthocyanins, Lycopene	Berries, Cherries, Tomatoes	Anti- inflammatory, Antioxidant	Reduces joint swelling and oxidative stress	Clinical and preclinical studies	(Roy et al., 2022)
Orange	Beta-carotene, Curcumin	Carrots, Pumpkin, Turmeric	Modulates immune response, Reduces TNF-α	Decreases inflammatio, Improves mobility	Several human trials	(Akbari et al., 2022)
Yellow	Curcuminoids, Lutein	Turmeric, Corn, Peppers	Inhibits COX-2, Reduces oxidative stress	Suppresses pro-inflammatory cytokines	Meta-analyses on curcumin	(Howes et al., 2020)
Green	Chlorophyll, Catechins	Spinach, Broccoli, Green Tea	Detoxification, Enhances immune regulation	Protects cartilage, Reduces RA flare-ups	Animal and cell-based studies	(Hayes & Ferruzzi, 2020)
Blue	Anthocyanins, Resveratrol	Blueberries, Black Grapes	Inhibits NF-κB, Reduces oxidative damage	Enhances joint collagen stability	Epidemiological studies	(Gonçalves et al., 2024)
Purple	Polyphenols, Resveratrol	Purple Sweet Potatoes, Red Cabbage	Scavenges free radicals, Regulates immune response	Improves joint flexibility,	Limited human trials	(Mallick et al., n.d.)

				Lowers inflammation		
White	Allicin, Quercetin	Garlic, Onion, Cauliflower	Modulates gut microbiota, Anti-inflammatory	Supports immune health, Lowers pain sensitivity	Studies on gut-immune axis	(Benameur et al., 2023)
Brown	Lignans, Polyphenols	Whole Grains, Flaxseeds	Regulates inflammatory markers, Antioxidant	Lowers systemic inflammatio, Supports gut health	Dietary intervention studies	(Senizza et al., 2020)
Multi-color	Mixed Polyphenols	Rainbow diet (Varied plant sources)	Synergistic effects, Balances immune response	Maximizes anti-RA benefits, Reduces oxidative stress	Review articles on plant-based diets	(Urasaki & Le, 2022)
Red-Purple	Anthocyanins, Flavonoids	Pomegranate, Red Grapes	Modulates inflammatory pathways, Strengthens blood vessels	Reduces joint stiffness and swelling	Observational studies	(Majdan & Bobrowska-Korczak, 2022)
Yellow-Green	Carotenoids, Polyphenols	Mango, Avocado, Peppers	Enhances cellular repair, Antioxidant	Protects joint tissues from oxidative damage	Preclinical studies	(Majdan & Bobrowska-Korczak, 2022)
Blue-Green	Phycocyanin, Chlorophyll	Spirulina, Algae	Anti-inflammatory, Enhances detoxification	Reduces joint degeneration	Experimental studies	(Liu et al., 2024)
White-Brown	Sulfur Compounds, Fiber	Mushrooms, Nuts, Seeds	Gut microbiome modulation, Antioxidant	Supports immune balance and reduces pain	Emerging research on microbiota	(Nathan & Nathan, 2020)
Orange-Red	Lycopene, Beta-carotene	Papaya, Watermelon	Reduces inflammatory cytokines, Protects tissues	Prevents joint degradation	Longitudinal studies	(Tufail et al., 2024)
Overall Impact	Combination of bioactive compounds	Balanced plant-based diet	Multi-targeted action on RA pathways	Improved symptom management and overall health	Requires further clinical validation	(Kumari et al., 2024)

4. PHYTOCHEMICALS AND THEIR COLOR-ASSOCIATED THERAPEUTIC POTENTIAL

4.1. Role of Plant Pigments in Health and Disease Management

Plant pigments, also known as phytochemicals, are bioactive compounds responsible for the vibrant colors of fruits, vegetables, and other plant-based foods. These pigments not only contribute to the visual appeal of plants but also play a crucial role in their protective mechanisms, such as shielding against ultraviolet (UV) radiation, pests, and oxidative stress. In human health, plant pigments have been extensively studied for their potential in disease prevention and management, particularly in conditions linked to chronic inflammation and oxidative stress, such as rheumatoid arthritis (RA)(Manzoor et al., 2021). Different classes of plant pigments have distinct therapeutic properties. Carotenoids, found in carrots, pumpkins, tomatoes, and bell peppers, exhibit strong antioxidant properties, reducing oxidative stress and supporting immune function. Lycopene, in particular, modulates inflammatory pathways by inhibiting pro-inflammatory cytokines. Flavonoids, present in citrus fruits, berries, onions, and tea, possess anti-inflammatory and immunomodulatory effects, regulating immune cells and protecting cartilage(Deis et al., 2021)(Iqbal, Altaf, Fatima, et al., 2024). Anthocyanins, abundant in berries, grapes, and red cabbage, scavenge reactive oxygen species (ROS) and suppress inflammatory mediators, offering joint protection. Chlorophyll, found in leafy greens, supports detoxification, enhances cellular repair, and reduces

oxidative damage, which is crucial in autoimmune diseases. By incorporating a variety of colorful plant-based foods into the diet, individuals with RA can benefit from the diverse therapeutic effects of these phytochemicals, potentially improving disease outcomes and overall health(Speciale et al., 2020).

4.2. Antioxidant and Anti-Inflammatory Properties of Plant Pigments

The therapeutic potential of plant pigments in RA management is largely attributed to their antioxidant and anti-inflammatory properties. Oxidative stress plays a central role in RA progression, as excessive ROS production contributes to joint damage, cartilage degradation, and immune system dysregulation. Plant pigments act as natural antioxidants by scavenging ROS, enhancing cellular antioxidant defenses, and preventing oxidative damage to tissues(Banik et al., 2020). Many plant pigments, including flavonoids and carotenoids, reduce pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β, which helps alleviate joint swelling, pain, and disease progression. Additionally, phytochemicals like curcumin and quercetin inhibit NF-κB activation, a key regulator of chronic inflammation, thereby reducing tissue damage. These pigments also modulate immune responses by regulating T-cell activity and reducing autoantibody production, which is beneficial in autoimmune conditions like RA. Furthermore, compounds such as anthocyanins and flavonoids help protect against cartilage degradation by inhibiting matrix metalloproteinases (MMPs), preserving joint function and mobility(Singh & Mazumder, 2023). Given their diverse therapeutic effects, plant pigments offer a promising natural approach to RA treatment. Incorporating phytochemical-rich foods into daily nutrition and exploring color-based dietary interventions may help reduce inflammation, improve joint health, and enhance overall well-being(Li et al., 2022).

4.3. Red Pigments: Anthocyanins and Carotenoids

Red pigments, including anthocyanins and carotenoids, are bioactive compounds in fruits and vegetables like berries, cherries, beets, and tomatoes. These pigments have strong antioxidant and anti-inflammatory properties that help manage rheumatoid arthritis. Anthocyanins reduce oxidative stress by neutralizing reactive oxygen species, while carotenoids like lycopene and beta-carotene inhibit inflammatory pathways. They suppress NF-κB activation, lowering pro-inflammatory cytokines such as TNF-α and IL-6, and enhance antioxidant enzymes like superoxide dismutase. Clinical studies suggest that regular consumption of anthocyanin- and carotenoid-rich foods can reduce inflammation, improve joint mobility, and alleviate pain, making them a valuable dietary approach for RA management(Fernández-López et al., 2020).

4.4. Yellow and Orange Pigments: Flavonoids and Carotenoids

Yellow and orange pigments, including flavonoids and carotenoids, are found in turmeric, carrots, and citrus fruits, offering anti-inflammatory and antioxidant benefits for rheumatoid arthritis. Flavonoids modulate immune responses, while carotenoids like beta-carotene and lutein neutralize reactive oxygen species, protecting joint tissues. These pigments inhibit pro-inflammatory cytokines such as TNF-α, IL-1β, and IL-6 by suppressing NF-κB signaling, reducing joint inflammation. Curcumin, from turmeric, is particularly potent, blocking inflammatory mediators and modulating immune function. Clinical studies suggest curcumin supplementation alleviates symptoms, decreases reliance on NSAIDs, and enhances quality of life, highlighting its therapeutic potential in arthritis management(Raina & Pandoh, n.d.). Incorporating yellow and orange pigmented foods into the diet may offer a natural and effective strategy for managing rheumatoid arthritis. The synergistic effects of flavonoids and carotenoids in reducing inflammation and oxidative stress highlight the importance of plant-based compounds in supporting joint health and overall disease management(Bas, 2024).

4.5. Green Pigments: Chlorophyll and Polyphenols

Green pigments, such as chlorophyll and polyphenols, found in leafy greens, spirulina, and matcha, offer detoxifying, immune-regulating, and anti-inflammatory benefits for rheumatoid arthritis. Chlorophyll supports liver detoxification, neutralizes toxins, and reduces oxidative stress, aiding joint protection. Polyphenols, including catechins from green tea, modulate immune responses, suppress pro-inflammatory cytokines like TNF-α and IL-6, and inhibit cartilage-degrading enzymes. These compounds restore immune balance and slow disease progression. Clinical studies show diets rich in green vegetables reduce inflammation, while EGCG from green tea and spirulina demonstrate protective effects against arthritis, highlighting the potential of green pigments in disease management(Ye et al., 2024). Incorporating green-pigmented foods into the diet can provide a natural, complementary approach to managing rheumatoid arthritis. The combination of chlorophyll's detoxifying properties and polyphenols' anti-inflammatory effects contributes to joint health, immune balance, and overall well-being(Bakhsh et al., 2023).

4.6. Blue and Purple Pigments: Anthocyanins and Polyphenols

Blue and purple pigments, including anthocyanins and polyphenols, found in blueberries, grapes, and purple sweet potatoes, offer therapeutic benefits for rheumatoid arthritis (RA). These compounds protect joints by inhibiting cartilage-degrading enzymes (MMPs) and stabilizing collagen. Their potent antioxidant properties reduce oxidative stress by neutralizing reactive oxygen species (ROS) and enhancing antioxidant enzymes like superoxide dismutase (SOD). Additionally, anthocyanins

suppress NF-κB activation, lowering pro-inflammatory cytokines (TNF-α, IL-6). Clinical studies show anthocyanin-rich foods reduce inflammation and pain in RA, while resveratrol and polyphenols from grapes and purple sweet potatoes support cartilage health and immune modulation, aiding RA management(Bakhsh et al., 2023)(Iqbal et al., n.d.).

Incorporating blue and purple pigmented foods into the diet offers a natural and effective strategy to complement conventional RA treatments. Their ability to protect joints, stabilize collagen, and counteract oxidative stress underscores their therapeutic potential in improving overall joint health and reducing disease severity(Lis & Bartuzi, 2023).

4.7. White and Brown Pigments: Polyphenols and Lignans

White and brown pigments, such as polyphenols and lignans, found in garlic, onions, sesame seeds, and whole grains, play a key role in rheumatoid arthritis (RA) management. These compounds regulate inflammatory pathways by inhibiting NF-κB signaling, reducing pro-inflammatory cytokines like TNF-α and IL-6. Additionally, polyphenols in whole grains modulate COX and LOX pathways, alleviating joint pain. Lignans and fiber-rich foods support gut microbiota balance, reducing systemic inflammation. Clinical studies highlight garlic, onions, and sesame seeds for their antioxidant and immune-modulating effects, making them valuable dietary components for RA management and overall joint health(Firdous et al., 2025)(Iqbal, Altaf, Salma, et al., 2024). Incorporating white and brown pigmented foods into the diet provides a holistic and natural approach to RA treatment. Their ability to modulate inflammatory pathways, support gut microbiota, and interact synergistically with other plant-based compounds highlights their therapeutic value in improving joint health and reducing RA symptoms(Saini et al., 2022).

5. SYNERGISTIC EFFECTS OF MULTI-COLOR DIET IN RA MANAGEMENT

A diverse, color-rich diet plays a crucial role in rheumatoid arthritis (RA) management by providing a wide range of bioactive compounds that work synergistically to combat inflammation, oxidative stress, and immune dysregulation. Unlike single-compound interventions, which focus on isolated phytochemicals, a multi-compound, plant-based dietary approach offers a broader spectrum of protective effects, enhancing overall joint health and reducing RA symptoms more effectively(Lopes et al., 2025).

5.1. Importance of Dietary Diversity and Nutrient Synergy

A diet rich in various plant pigments ensures a balanced intake of antioxidants, polyphenols, flavonoids, carotenoids, and lignans, each contributing uniquely to RA management. Red anthocyanins, yellow and orange carotenoids, green chlorophyll, blue and purple polyphenols, and white and brown lignans all interact to modulate inflammatory pathways, stabilize collagen, and enhance immune function. This diversity optimizes cellular protection and metabolic processes, preventing excessive oxidative damage and inflammatory cascades that exacerbate RA symptoms(Muscolo et al., 2024).

5.2. Comparison of Single-Compound vs. Multi-Compound Plant-Based Approaches

While individual plant compounds like curcumin from turmeric or resveratrol from grapes have demonstrated significant anti-inflammatory and antioxidant effects, they often show greater efficacy when consumed as part of a whole-food, multi-compound diet. Research suggests that phytochemicals exhibit additive or even synergistic effects, meaning their combined impact on inflammation and immune modulation surpasses that of isolated compounds. For example, anthocyanins from berries enhance the anti-inflammatory effects of flavonoids found in citrus fruits, while lignans in sesame seeds complement the immune-regulating properties of polyphenols in green tea. This interplay enhances bioavailability, allowing for more efficient absorption and utilization of nutrients(Banez et al., 2020).

5.3. Holistic Impact on Inflammation and Immune Balance

A multi-color diet contributes to holistic RA management by addressing multiple disease mechanisms simultaneously. Polyphenols and carotenoids neutralize reactive oxygen species (ROS), reducing oxidative stress that damages joint tissues. Flavonoids and lignans inhibit pro-inflammatory cytokines like tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), thereby preventing chronic inflammation and joint degradation. Furthermore, dietary fiber from whole grains and leafy greens supports gut microbiota, promoting immune balance and reducing autoimmunity associated with RA(Croce, 2021)(Mushtaq et al., n.d.). By integrating a variety of colorful, plant-based foods into the diet, individuals with RA can benefit from a comprehensive, natural approach to disease management. This dietary strategy not only alleviates inflammation and joint discomfort but also supports overall health, reinforcing the importance of food as medicine in chronic disease prevention and treatment(Croce, 2021).

6. CHALLENGES AND FUTURE PERSPECTIVES

Despite promising findings, plant-based color therapy for rheumatoid arthritis (RA) faces several challenges. Current research is limited, with most studies focusing on in vitro or animal models rather than large-scale human trials. The variability in plant compound concentrations across different food sources complicates standardization, making it difficult to determine optimal dosages for therapeutic effects. Additionally, bioavailability issues may limit the effectiveness of certain phytochemicals, requiring further exploration of delivery mechanisms(Saadh et al., 2024).

To establish credibility, well-designed clinical trials are needed to assess the efficacy and safety of plant pigments in RA management. Standardized dosages and formulation techniques, such as encapsulation or nano-delivery systems, could enhance therapeutic potential. Future research should also explore the integration of color therapy with conventional RA treatments, potentially reducing reliance on pharmaceuticals while improving patient outcomes. A holistic, evidence-based approach combining plant-based therapies with existing medical interventions may offer a more sustainable solution for RA management(Ufomadu et al., 2025)(Iqbal et al., 2023).

7. CONCLUSION

Plant-based color therapy presents a promising complementary approach for managing rheumatoid arthritis (RA) by leveraging the anti-inflammatory, antioxidant, and immune-modulating properties of naturally occurring pigments. Research highlights the therapeutic potential of anthocyanins, carotenoids, flavonoids, polyphenols, and lignans in reducing oxidative stress, stabilizing collagen, and modulating inflammatory pathways. A multi-color diet enhances nutrient synergy, offering broader protective effects compared to single-compound interventions. While preliminary studies suggest benefits, more clinical research is needed to validate efficacy, determine optimal dosages, and address bioavailability challenges. Standardized formulations and targeted delivery systems may improve therapeutic outcomes. Integrating plant-based color therapy with conventional RA treatments could reduce dependency on pharmaceuticals and enhance overall disease management. Future research should focus on clinical trials, personalized dietary strategies, and mechanistic studies to establish evidence-based guidelines. A holistic approach incorporating plant-based therapies may offer a sustainable, natural solution for improving RA symptoms and patient health.

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