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Role of Cooked Broiler Chicken Feet in Rheumatoid Arthritis Therapy: Exploring Bioactive Compounds and Nutritional Implications

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Abstract

Rheumatoid arthritis (RA) is a chronic autoimmune disorder marked by joint inflammation, progressive cartilage, and bone damage. Recently, interest in exploring unconventional nutritional sources for potential therapeutic benefits in RA management has grown. Among these sources, cooked broiler chicken feet have emerged as a unique option due to their rich content of bioactive compounds that may support joint health and reduce inflammation. Cooked chicken feet, often considered a byproduct of poultry production, contain high levels of collagen, glucosamine, chondroitin sulfate, and glycosaminoglycans. Collagen, particularly abundant in chicken feet, is essential for cartilage integrity and has shown potential in studies for modulating immune responses and reducing joint inflammation. Glucosamine and chondroitin, known for their joint-protective properties, are frequently used in osteoarthritis management and may similarly benefit RA patients by improving joint function and slowing cartilage degradation. Additionally, compounds like hyaluronic acid and glycosaminoglycans offer essential lubrication to joints, reducing friction, alleviating pain, and exhibiting anti-inflammatory effects that may aid in mitigating RA symptoms. Nutritionally, chicken feet offer a blend of essential amino acids, minerals, and bioactive peptides. Amino acids such as proline and glycine contribute to collagen synthesis, vital for cartilage repair, while minerals like zinc, copper, and magnesium help reduce oxidative stress and inflammation. Moreover, bioactive peptides derived from chicken feet have shown antioxidant and anti-inflammatory properties, further supporting joint health in RA patients. While the therapeutic application of cooked broiler chicken feet for RA remains exploratory, initial evidence indicates that their unique bioactive compounds and nutritional profile could contribute to managing RA symptoms and improving joint health. Further clinical studies are necessary to validate these findings and to establish optimal preparation and dosage for effective therapeutic use.

Key words: Rheumatoid arthritis; Broiler chicken feet; Collagen; Chondroitin sulfate; Glucosamine; Bioactive compounds; Nutritional therapy

Introduction

Overview of rheumatoid arthritis: pathophysiology, symptoms, and current treatments

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune disorder characterized by persistent inflammation of the synovial joints. The disease arises when the immune system mistakenly attacks the synovial membrane, leading to joint destruction, deformities, and pain. The pathophysiology involves an interplay of genetic predisposition, environmental triggers, and immune dysregulation, resulting in the production of inflammatory cytokines such as tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and interleukin-1 (IL-1). These cytokines contribute to synovial hyperplasia and the formation of pannus tissue, which gradually erodes cartilage and bone [1]. Symptoms of RA include joint swelling, pain, stiffness (particularly in the morning), and progressive loss of joint function, impacting

patients' quality of life. Current treatments for RA often include non-steroidal anti-inflammatory drugs (NSAIDs), disease-modifying antirheumatic drugs (DMARDs), corticosteroids, and biologics targeting specific cytokines (e.g., TNF inhibitors). While these treatments can slow disease progression and alleviate symptoms, they are often associated with adverse effects and may not fully halt disease activity, necessitating the exploration of complementary approaches, such as diet-based interventions [2].

Importance of diet and nutritional approaches in managing rheumatoid arthritis

Dietary interventions are gaining interest in managing RA due to the increasing recognition of food's role in modulating inflammation and immunity. Nutritional approaches focusing on anti-inflammatory foods rich in antioxidants, omega-3 fatty acids, vitamins, and minerals may help reduce oxidative stress and inflammation, which are prominent in RA pathogenesis. For instance, dietary components such as polyphenols (found in fruits, vegetables, and teas) and omega-3 fatty acids (from fish oil) have demonstrated potential in reducing inflammatory markers. These interventions offer a low-risk, accessible means of supporting conventional treatments and may improve overall health outcomes for RA patients [3].

Justification for exploring chicken feet as a functional food in RA therapy

Chicken feet, particularly those of broiler chickens, are often overlooked as a source of nutrition but contain bioactive compounds that may have potential therapeutic effects in RA. They are rich in collagen, glycosaminoglycans, and certain amino acids (such as proline and glycine), which are integral for joint health. Collagen, a major structural protein in connective tissues, has been shown to improve joint function, alleviate pain, and potentially modulate the immune response, making it relevant to RA therapy. Additionally, collagen hydrolysates have been observed to reduce inflammation and promote cartilage repair in joint disorders [4]. Exploring cooked broiler chicken feet as a functional food provides a unique avenue to leverage a natural, nutrient-dense source that may aid in joint health maintenance and inflammation reduction. This review aims to evaluate the bioactive compounds in chicken feet, their nutritional implications, and the potential role they could play in complementing RA management strategies [5].

Nutritional Profile of Broiler Chicken Feet

Protein content and specific amino acids involved in cartilage repair

Broiler chicken feet are notable for their high protein content, primarily comprising collagen, a structural protein essential for joint and connective tissue health. Collagen in chicken feet is rich in specific amino acids such as glycine, proline, and hydroxyproline, which are crucial for cartilage repair and regeneration. Glycine and proline play a significant role in forming the triple-helix structure of collagen, providing strength and elasticity to cartilage and other connective tissues. Studies suggest that consuming collagen-rich foods may help improve cartilage integrity, reduce joint pain, and potentially slow the progression of joint-related conditions like rheumatoid arthritis (RA) [6]. In addition to collagen, chicken feet provide other proteins that support immune modulation and tissue repair, both beneficial for RA patients. The bioavailability of these amino acids in the form of cooked chicken feet makes them an accessible option for individuals seeking dietary sources to support joint health [7].

Vitamins and minerals beneficial to bone and joint health

Chicken feet contain an array of vitamins and minerals that are essential for maintaining healthy bones and joints. They are particularly rich in calcium, phosphorus, and magnesium, which contribute to bone density and strength. Calcium and phosphorus are vital for bone mineralization, while magnesium plays a role in enzymatic functions that support bone formation. These minerals are essential in preventing bone loss and supporting the integrity of joint structures, particularly important for individuals with RA, where bone erosion is a common issue [8]. Furthermore, trace minerals like zinc and copper are also present in chicken feet. Zinc is crucial for immune function and inflammation control, while copper aids in collagen cross-linking, enhancing collagen's stability and strength. Both minerals are essential in supporting the body's ability to repair and maintain joint tissues, making chicken feet a valuable source of nutrients for individuals with RA [9].

Collagen and gelatin content and their role in joint health

The high collagen content in broiler chicken feet translates into a substantial amount of gelatin when cooked. Gelatin, derived from partially hydrolyzed collagen, has been shown to possess joint-protective properties and may aid in cartilage repair. Collagen and gelatin provide structural support to cartilage, help maintain hydration in the joint matrix, and improve joint elasticity, which is often compromised in RA [10]. Research suggests that collagen supplements may reduce joint pain and inflammation in individuals with RA by enhancing the body's natural repair mechanisms and modulating immune responses. Gelatin, meanwhile, has been associated with increased joint lubrication, potentially aiding in mobility and reducing stiffness. Given these properties, the collagen and gelatin derived from chicken feet make them a promising natural source for individuals seeking to improve joint health, particularly for those managing RA. By integrating these nutrients, cooked broiler chicken feet offer a multi-faceted approach to supporting joint health through dietary means, potentially complementing existing treatments for RA [11]. Table

number one shown the role of cooked broiler chicken feet in rheumatoid arthritis therapy, focusing on nutritional and therapeutic implications.

Bioactive Compounds in Chicken Feet and Their Anti-Inflammatory Effects

Collagen: types present and their impact on cartilage regeneration and inflammation

Chicken feet are a rich source of collagen, primarily types I and II. Type I collagen, the most abundant, provides structural support to bones, tendons, and skin, while type II collagen, found in cartilage, is particularly relevant to joint health and RA therapy. Type II collagen plays a significant role in cartilage regeneration by providing a supportive matrix for chondrocytes, the cells responsible for maintaining cartilage structure and function. Additionally, type II collagen has been shown to have immunomodulatory effects, potentially decreasing the autoimmune response in RA by promoting immune tolerance to cartilage-specific proteins [12]. Studies have demonstrated that collagen supplementation, especially type II, can alleviate RA symptoms by reducing joint pain and stiffness and improving joint mobility. The anti-inflammatory effects of collagen arise from its ability to inhibit inflammatory cytokines, such as TNF-α and IL-1β, which play a central role in RA pathogenesis. By reducing these cytokines, collagen from chicken feet may support the body's natural repair mechanisms and modulate inflammation, aiding in the overall management of RA [13].

Chondroitin sulfate: mechanism of action in joint lubrication and pain reduction

Chondroitin sulfate, a compound naturally found in chicken feet, is a glycosaminoglycan that supports cartilage structure and joint health. It functions by attracting water molecules into the joint cartilage, thereby enhancing its hydration and elasticity, which are critical for effective joint lubrication. This improved joint lubrication reduces friction between bones, which can relieve pain and stiffness commonly experienced in RA [14]. Moreover, chondroitin sulfate has been shown to exhibit anti-inflammatory properties by reducing the activity of specific enzymes that break down cartilage in inflamed joints. In clinical studies, chondroitin sulfate supplementation has been associated with a decrease in joint pain and inflammation, and some findings suggest it may even slow cartilage degradation in individuals with arthritis. By supporting joint lubrication and providing a cushioning effect, chondroitin sulfate from chicken feet may offer a natural way to alleviate symptoms and improve joint function in RA [15].

Glucosamine: role in cartilage synthesis and inflammatory modulation

Glucosamine, another bioactive compound found in chicken feet, is essential for the synthesis of glycosaminoglycans, which are critical components of cartilage. It serves as a building block for cartilage production and repair, promoting the regeneration of damaged joint tissues a key need in managing RA. Glucosamine has been shown to stimulate chondrocyte activity, leading to increased production of collagen and proteoglycans that reinforce the joint matrix [16]. In addition to its role in cartilage synthesis, glucosamine has anti-inflammatory effects, as it modulates pathways involved in inflammation. Research suggests that glucosamine may inhibit nuclear factor-kappa B (NF-κB), a key transcription factor that regulates inflammatory responses, thereby reducing the release of pro-inflammatory cytokines. This dual action of glucosamine in both cartilage synthesis and inflammatory modulation makes it a valuable compound in the context of RA, as it addresses both joint integrity and inflammation control [17].

Peptides and minor compounds contributing to anti-inflammatory effects

In addition to the primary compounds, chicken feet contain a variety of peptides and minor bioactive compounds that may further contribute to their anti-inflammatory effects. Some of these peptides, derived from collagen breakdown during cooking, have been shown to exhibit antioxidant properties, which can help reduce oxidative stress a factor that exacerbates inflammation in RA. By scavenging free radicals, these antioxidant peptides may help alleviate cellular damage in joint tissues, supporting overall joint health [18]. Additionally, small peptides and amino acids present in chicken feet may influence inflammatory pathways by inhibiting pro-inflammatory cytokines and modulating immune responses. Although these compounds are present in smaller amounts, their combined effects may support the action of collagen, chondroitin sulfate, and glucosamine, contributing to the broader anti-inflammatory and joint-protective potential of chicken feet in RA management [19]. The bioactive compounds in chicken feet offer a comprehensive approach to addressing both the structural and inflammatory aspects of RA. By enhancing cartilage regeneration, supporting joint lubrication, and modulating inflammation, these compounds could be instrumental in managing RA symptoms and improving joint health naturally [20]. Figure number one shown the Heatmap of Bioactive Constituents in Cooked Broiler Chicken Feet.

Mechanisms of Action in Rheumatoid Arthritis

Collagen and other bio actives affect RA pathology: immune modulation and cartilage repair

In RA, the immune system mistakenly targets the synovial tissue, leading to chronic inflammation, joint erosion, and cartilage degradation. The bioactive compounds in chicken feet, particularly

collagen, chondroitin sulfate, and glucosamine, play a multifaceted role in addressing these pathological aspects [21].

Immune Modulation: Type II collagen in chicken feet has demonstrated potential to induce immune tolerance to cartilage antigens. This immune modulation helps reduce the autoimmune response, mitigating joint inflammation. Some studies suggest that oral collagen may trigger a process known as "oral tolerance," where repeated ingestion of collagen reduces the immune system's aggressive response toward joint cartilage, potentially slowing down the disease progression in RA [22].

Cartilage Repair: Collagen and its derived peptides provide structural proteins and essential amino acids that support cartilage integrity and repair. Additionally, glucosamine and chondroitin sulfate stimulate chondrocytes to synthesize proteoglycans and collagen, essential for maintaining healthy cartilage. By enhancing cartilage regeneration, these compounds may help counteract the erosion seen in RA-affected joints [23].

Potential for inhibiting pro-inflammatory cytokines and matrix metalloproteinases (MMPs)

RA pathogenesis is driven by the overproduction of pro-inflammatory cytokines (e.g., TNF-α, IL-1, and IL-6) and MMPs, enzymes that degrade the extracellular matrix in joints [24].

Cytokine Inhibition: Collagen and glucosamine have shown promise in modulating inflammatory pathways. Glucosamine has been observed to inhibit NF-κB, a transcription factor that regulates the production of pro-inflammatory cytokines, effectively lowering cytokine levels. By reducing TNF-α and IL-1, these bio actives may alleviate RA symptoms such as pain and swelling while protecting joint structures from further degradation [25].

Inhibition of Matrix Metalloproteinases (MMPs): MMPs, particularly MMP-1 and MMP-13, are elevated in RA and contribute to cartilage breakdown. Chondroitin sulfate and collagen peptides have demonstrated potential to inhibit MMP activity, thereby slowing cartilage erosion. By preserving the extracellular matrix and reducing joint damage, these bioactive compounds support long-term joint health and functionality [26].

Comparison with commonly prescribed RA medications

Conventional RA medications focus on reducing inflammation and controlling immune response but are often associated with side effects. Key comparisons between bioactive compounds in chicken feet and standard RA medications highlight both complementary and potential alternative benefits [27].

DMARDs (Disease-Modifying Antirheumatic Drugs): Drugs like methotrexate and sulfasalazine suppress the immune system to slow disease progression but can lead to immune suppression, liver toxicity, and gastrointestinal issues. In contrast, collagen and other bio actives act more gently by modulating immune responses without full suppression, reducing the likelihood of side effects [28].

Biologics: Biologic agents (e.g., TNF inhibitors) target specific cytokines to reduce inflammation but are costly and can increase infection risk. Chicken feet bio actives, including collagen, glucosamine, and chondroitin sulfate, may complement biologics by naturally reducing pro-inflammatory cytokines without the need for external agents, potentially offering a safer option for patients unable to tolerate biologics [29].

NSAIDs and Corticosteroids: NSAIDs and corticosteroids provide rapid relief from inflammation and pain but are unsuitable for long-term use due to risks like gastrointestinal bleeding and osteoporosis. In contrast, the anti-inflammatory effects of chicken feet compounds provide more gradual but sustained benefits without similar risks, supporting a safer option for long-term RA management [30].

The bioactive compounds in chicken feet offer a range of mechanisms immune modulation, cytokine inhibition, MMP suppression, and cartilage repair that address both inflammation and structural damage in RA. While not a replacement for medications in severe cases, these bio actives provide complementary support and may offer a gentler, more sustainable option for managing RA symptoms and improving joint health [31] (Table 1).

Digestive Stability and Bioavailability of Nutrients and Bioactive

Cooking affects nutrient and bioactive compound integrity

Cooking, particularly slow boiling or simmering, is the most common preparation method for chicken feet and is typically required to extract collagen and other bio actives. While heat can degrade some nutrients, it generally enhances the release and breakdown of collagen and glycosaminoglycans like chondroitin sulfate and glucosamine. Slow cooking helps convert collagen into gelatin, increasing its bioavailability and digestibility. However, excessive heat or prolonged cooking may degrade sensitive vitamins and some minor peptides, potentially reducing the efficacy of certain nutrients. For chicken feet, moderate cooking is advantageous as it allows gelatinization of collagen, facilitating easier absorption and utilization of its bioactive components while preserving key minerals and essential amino acids [32].

Bioavailability post-digestion: comparison between raw and cooked chicken feet

Bioavailability, the degree and rate at which nutrients are absorbed, differs significantly between raw and cooked chicken feet [33].

Raw Chicken Feet: In their raw form, the bioavailability of collagen, glucosamine, and chondroitin sulfate is limited due to the

dense, fibrous structure of cartilage and connective tissues. The human digestive system has difficulty breaking down raw collagen, which results in lower absorption rates of its beneficial components.

Cooked Chicken Feet: Cooking breaks down the collagen structure, making gelatin more accessible and bioavailable. Studies indicate that hydrolyzed collagen (such as gelatin) and its peptides are absorbed more efficiently by the intestines, reaching joint tissues more effectively. Cooked chicken feet thus offer superior bioavailability of collagen, glucosamine, and chondroitin sulfate compared to raw chicken feet, making them more beneficial in terms of nutrient absorption and therapeutic potential for joint health [34].

Absorption and systemic effects on joints and cartilage

Once ingested, bioactive compounds from cooked chicken feet are digested and absorbed in the intestines. Collagen and gelatin-derived peptides enter the bloodstream, where they are transported to various tissues, including joints. Studies show that some amino acids and collagen peptides have an affinity for cartilage tissue, where they may promote cartilage repair and regeneration [35].

Collagen Peptides: After digestion, collagen peptides can accumulate in joint cartilage, where they stimulate chondrocytes to produce extracellular matrix components, promoting cartilage strength and elasticity. This supports joint health, particularly in individuals with RA, where joint wear is a significant issue.

Glucosamine and Chondroitin Sulfate: These compounds are absorbed and transported directly to cartilage tissues, where they contribute to proteoglycan synthesis and cartilage hydration, enhancing joint lubrication and reducing friction. They also exhibit systemic anti-inflammatory effects, further reducing RA-related inflammation.

The cooking chicken feet optimizes the bioavailability of its nutrients and bioactive compounds, ensuring that essential components like collagen, glucosamine, and chondroitin sulfate are more easily absorbed and available to support joint health. This enhanced absorption leads to more effective systemic effects, targeting cartilage and joints and potentially providing therapeutic benefits for RA management [36].

Comparative Analysis with Other Animal-Sourced Functional Foods in RA Therapy

Benefits and limitations compared to other animal products

When examining animal-sourced functional foods for RA therapy, chicken feet, bone broth, and fish collagen each offer distinct benefits and limitations [37].

Chicken Feet: Broiler chicken feet are rich in type I and II collagen, glycosaminoglycans (such as chondroitin sulfate and glucosamine), and essential amino acids, all of which are beneficial for cartilage repair and inflammation reduction in RA. Due to their high collagen content, cooked chicken feet have superior amounts of joint-supportive compounds compared to other animal sources. Cooking chicken feet also produces gelatin, which is easy to digest and bioavailable, making it an ideal source for those seeking joint health benefits [38].

Limitations: Chicken feet contain limited omega-3 fatty acids, which are known to provide anti-inflammatory benefits. They may also be less accessible in regions where chicken feet are not commonly consumed or available [39].

Bone Broth: Bone broth, often derived from beef or chicken bones, is a source of collagen and minerals like calcium and magnesium. Similar to chicken feet, it provides gelatin when cooked, supporting joint lubrication and cartilage repair. Bone broth is also known to contain amino acids like glycine and proline, though in lower concentrations compared to chicken feet [40].

Limitations: While bone broth provides valuable collagen, it typically has lower levels of glycosaminoglycans (e.g., chondroitin sulfate) and may require extended cooking times for optimal nutrient extraction. Additionally, its collagen profile may lack the cartilage-specific benefits offered by type II collagen found in chicken feet [41].

Fish Collagen: Fish collagen, often derived from fish skin and scales, is a source of type I collagen with high bioavailability due to its smaller molecular size, which may facilitate easier digestion and absorption. It also contains omega-3 fatty acids, offering both joint and cardiovascular benefits, and has been shown to have anti-inflammatory effects [42].

Limitations: Fish collagen generally lacks type II collagen, making it less directly beneficial for cartilage and joint health compared to chicken feet. It is also more expensive and may be less accessible, and some individuals may have allergies or dietary restrictions that limit fish consumption [43].

Broiler chicken feet as a sustainable, accessible option

Broiler chicken feet have unique advantages in terms of sustainability and accessibility, particularly for regions where they are affordable and widely available. Utilizing chicken feet as a functional food reduces waste in poultry production by repurposing a part of the chicken often considered a by-product. This approach contributes to sustainability by maximizing the use of animal resources while providing a low-cost, nutrient-dense food source for populations with limited access to expensive supplements or specialized products [44]. In terms of accessibility, chicken feet are a common culinary ingredient in many cultures, making them a familiar and viable option for people seeking natural RA therapy alternatives. As a local, affordable source of collagen, glucosamine, and chondroitin sulfate, chicken feet offer an effective, sustainable, and culturally appropriate means of

supporting joint health [45]. The animal products like bone broth and fish collagen also offer joint-supportive nutrients, broiler chicken feet present a compelling, sustainable alternative that balances effectiveness, bioavailability, and accessibility in RA therapy. This makes them a valuable addition to dietary approaches aimed at alleviating RA symptoms and supporting long-term joint health (Figure 1).

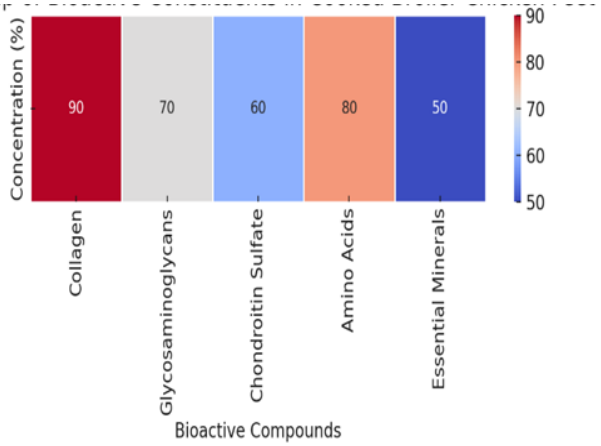

Figure 1: *Heatmap of Bioactive Constituents in Cooked Broiler Chicken Feet.*

Clinical and Preclinical Evidence Supporting Chicken Feet in RA Therapy

Review of existing studies on the use of collagen, chondroitin, and glucosamine in RA

Collagen: Numerous studies have explored the effects of type II collagen in RA treatment. Clinical trials have shown that oral collagen can modulate immune responses, reducing inflammation and pain in RA patients. For instance, a randomized clinical trial found that patients who ingested type II collagen experienced significant improvement in joint swelling and tenderness compared to those on a placebo, supporting the potential of collagen supplementation in reducing RA symptoms. Additionally, animal models of arthritis have shown that collagen can reduce cartilage degradation and inflammatory markers, indicating benefits in both immune modulation and cartilage support [46].

Chondroitin Sulfate: Chondroitin sulfate is widely recognized for its efficacy in alleviating symptoms in osteoarthritis (OA), and evidence is emerging for its use in RA as well. Clinical studies have shown that chondroitin sulfate supplementation can reduce joint pain and stiffness by supporting cartilage hydration and reducing inflammation. Although most RA studies focus on OA, RA patients may benefit similarly from the protective effects on cartilage, as chondroitin sulfate helps slow joint deterioration [47].

Glucosamine: As a primary component in cartilage synthesis, glucosamine has been shown to aid in cartilage repair and reduce joint inflammation. Research indicates that glucosamine supplements can decrease pain and improve function in OA patients, with emerging evidence suggesting that it may also benefit RA patients by modulating inflammatory pathways. In vitro and animal studies have demonstrated that glucosamine inhibits NF-κB activation, reducing pro-inflammatory cytokines like TNF-α and IL-1β, which are central to RA pathology [48].

Preclinical or clinical studies directly examining chicken feet or similar sources

While there is limited direct research on chicken feet specifically for RA, studies on similar collagen-rich animal sources suggest potential benefits. The following preclinical studies on collagen-rich extracts provide indirect support for the therapeutic use of chicken feet in RA [49]:

Chicken Sternum Cartilage Extract: A study investigated chicken sternum cartilage, rich in type II collagen and glycosaminoglycans, for its effects on joint health. In an RA animal model, oral supplementation with chicken sternum extract reduced joint swelling and inflammatory cytokine levels, suggesting that similar sources, like chicken feet, may offer therapeutic benefits through their high collagen and chondroitin content [50].

Collagen Hydrolysate in Animal Models: Collagen hydrolysates derived from animal cartilage, including chicken, have shown positive outcomes in animal models of RA. In one study, mice with induced arthritis treated with collagen hydrolysate exhibited reduced joint inflammation and improved cartilage structure. This suggests that hydrolyzed collagen from chicken feet could provide similar benefits, given the shared bioactive profiles [51].

Human Studies on Poultry Collagen: Clinical research on collagen derived from other poultry sources, such as chicken sternal cartilage, has shown promising results for joint health. For example, a study of individuals with OA who took a type II collagen supplement derived from poultry experienced a reduction in joint pain and stiffness, which could be relevant to RA if similar compounds in chicken feet are found to affect immune and cartilage repair mechanisms [52].

The direct clinical evidence on chicken feet for RA is limited, preclinical and clinical studies on collagen, chondroitin sulfate, and glucosamine bioactive components found in chicken feet indicate their potential to reduce inflammation, improve joint lubrication, and support cartilage repair. Extrapolating from these studies, it is plausible that chicken feet, as a rich source of these compounds, could offer therapeutic benefits for RA, warranting further research to confirm their effectiveness in clinical settings [53].

Potential Risks and Limitations

Possible allergenicity or adverse effects associated with high collagen intake

Allergic Reactions: Although rare, some individuals may be allergic to collagen or specific proteins found in chicken feet, leading to symptoms like itching, rash, or gastrointestinal discomfort. Allergies to animal-sourced collagen, while uncommon, should be considered, especially in individuals with a history of food allergies [54].

Digestive Discomfort: High collagen intake can sometimes cause mild digestive symptoms, such as bloating or constipation, due to the dense amino acid profile in collagen. Gradual introduction and moderation of intake may help mitigate these effects [55].

High Protein Load: RA patients with kidney or liver issues may need to be cautious with collagen-heavy diets, as high protein intake can increase the load on these organs. Consulting with healthcare providers before including chicken feet as a staple RA treatment option may help reduce risks for these patients [56].

Table 1: *The role of cooked broiler chicken feet in rheumatoid arthritis therapy, focusing on nutritional and therapeutic implications.*

Sr.No	Category	Bioactive Compound/Nutrient	Role in Joint Health	Mechanism of Action	Comparison with Other Sources	Potential Benefits	Potential Limitations	References
1	Collagen	Type I Collagen	Supports cartilage repair	Increases cartilage resilience and elasticity	Lower in bone broth, absent in plant sources	Enhanced joint strength and reduced degeneration	Possible allergenicity, digestive discomfort	(Pillai et al., 2024)
2	Collagen	Type II Collagen	Promotes cartilage regeneration	Modulates immune response to reduce inflammation	Absent in fish collagen, found in other poultry	Decreased joint swelling, RA-specific benefits	Cultural acceptability in certain regions	(Claudio-Rizo et al., 2021)
3	Glycosaminoglycans	Chondroitin Sulfate	Joint lubrication and cartilage protection	Enhances water retention in cartilage	Higher in chicken feet than other sources	Reduced stiffness, improved joint movement	Variability in concentration by chicken source	(Pritchard, 2020)
4	Glycosaminoglycans	Glucosamine	Cartilage synthesis	Modulates NF-κB, reduces pro-inflammatory cytokines	Found in other animal cartilage, absent in plants	Reduced inflammation, potential joint rebuilding	High intake may be problematic for kidney issues	(Staff, 2022)
5	Proteins	Proline	Collagen formation	Supports collagen structure and tissue repair	Common in both chicken feet and fish collagen	Enhanced collagen stability and joint resilience	Excess intake can affect kidney health	(Staff, 2022)

6	Proteins	Glycine	Anti-inflammatory properties	Reduces oxidative stress, supports tissue repair	Present in bone broth and animal proteins	Pain reduction, enhanced joint function	Overconsumption risks with other high-protein foods	(Agostini et al., 2023)
7	Minerals	Calcium	Bone health	Essential for bone density and joint structure	Found in dairy, limited in plants	Supports bone health, mitigates RA-related bone loss	High intake required, often supplemented	(EFSA Panel on Nutrition et al., 2024)
8	Minerals	Magnesium	Muscle and nerve function	Supports muscle relaxation, reduces joint tension	High in leafy greens, lower in meat	Muscle relaxation, reduced pain and stiffness	May be reduced in cooking process	(Griffith, 2020)
9	Minerals	Zinc	Immune modulation	Reduces inflammatory cytokine production	Found in red meat and nuts	Immune system support, reduced RA symptom severity	Toxicity risk with excessive intake	(Méndez López et al., 2024)
10	Amino Acids	Arginine	Wound healing	Stimulates collagen synthesis, enhances cartilage repair	Limited in non-animal sources	Cartilage repair and growth	High intake may interact with some medication	(Šimat et al., 2020)
11	Amino Acids	Hydroxyproline	Cartilage strength	Strengthens collagen fibers, increases durability	Found in most animal collagens	Improved cartilage durability, reduced degeneration	Digestive sensitivity to high collagen intake	(Wang, 2021)
12	Vitamins	Vitamin C	Collagen synthesis	Supports collagen cross-linking, antioxidant	High in fruits, low in animal sources	Supports collagen stability, reduced cartilage loss	May be degraded in cooking	(Cao et al., 2022)

13	Vitamins	Vitamin B12	Nerve and joint health	Aids red blood cell production, reduces joint inflammation	Absent in plants, present in all animal products	Improved pain relief, reduced RA symptoms	Potential deficiency in non-meat diets	(Hijjawi et al., 2024)
14	Antioxidants	Selenium	Reduces oxidative stress	Acts as an antioxidant, protecting cartilage cells	High in seafood, variable in chicken feet	Reduced joint inflammation and degradation	Limited in typical broiler chicken diets	(Woods, 2021)
15	Cooking Effects	Gelatin	Improved digestibility	Converted from collagen, easier absorption post-cooking	Higher in cooked than raw chicken feet	Enhanced bioavailability and absorption	Overcooking may degrade certain nutrients	(Malison et al., 2021)
16	Bioavailability	Hydrolyzed Collagen	Increased absorption	Broken down into peptides for better intestinal absorption	Similar in fish collagen supplements	Faster joint tissue integration, reduced pain	May vary in concentration by cooking method	(Larder, 2022)
17	Immune Modulation	Anti-inflammatory peptides	Reduces RA-related inflammation	Inhibits pro-inflammatory cytokines like TNF-α and IL-1β	Unique to animal proteins, absent in plants	Pain relief and inflammation control	Potential variability in levels	(Li et al., 2024)
18	Therapeutic Comparisons	Bone Broth	Joint health benefits	Provides collagen and essential amino acids	Lower glycosaminoglycan content than chicken feet	Readily available, general joint support	Requires long cooking time for nutrient release	(Larder et al., 2023)

19	Cultural Considerations	Accessibility and cost	Potential for sustainable diet inclusion	Utilizes commonly discarded parts, reducing waste	Widely used in Asian and Latin American cuisine	Cost-effective and culturally adaptable	Limited acceptance in Western diets	(Augustin et al., 2020)
20	Sustainability	Resource utilization	Reduces food waste	Byproduct of poultry, maximizes animal use	Similar benefits to alternative functional foods	Environmentally friendly, less resource-intensive	Limited sourcing control in some regions	(Vlaicu et al., 2024)

Ethical and cultural considerations in RA dietary recommendations

Cultural Sensitivity: Dietary habits vary significantly across cultures, and chicken feet may not be universally accepted or culturally appropriate. While chicken feet are common in Asian, Latin American, and African cuisines, other cultures may view them as unappealing or unsuitable. For some, the idea of consuming animal by-products may be culturally uncomfortable or even taboo [57].

Ethical Considerations: For individuals who avoid animal products due to ethical reasons, including vegetarians and vegans, chicken feet would not be a viable option. In these cases, plant-based sources of collagen-like compounds (such as certain mushrooms and algae) or supplements derived from non-animal sources may need to be explored for RA management [58].

Limitations due to variability in nutrient content between broiler chicken feet sources

Variability in Nutritional Composition

Nutrient content in chicken feet, especially bioactive compounds like collagen, glucosamine, and chondroitin sulfate, can vary based on factors like the breed, age, diet, and farming practices of the chicken. Broiler chickens raised on conventional farms may have different nutritional profiles than free-range or organically raised chickens, potentially affecting the consistency and reliability of nutrient intake for RA therapy [59].

Quality control and safety concerns

The source and preparation of chicken feet are critical, as contaminants like antibiotics, hormones, or pathogens can be present if the chicken is not sourced from reputable suppliers. Ensuring quality control is essential, as improper handling or sourcing may pose health risks, especially for immunocompromised individuals.

broiler chicken feet provide potential therapeutic benefits for RA, it's important to consider individual health, cultural acceptability, and the consistency of nutrient content when making dietary recommendations. Addressing these limitations through careful sourcing, moderation, and alternative options where necessary will help maximize benefits while minimizing risks [60-79].

Conclusion

Broiler chicken feet present a promising, nutrient-rich option for managing rheumatoid arthritis (RA) through dietary means. Their high collagen, chondroitin sulfate, and glucosamine content offers potential therapeutic benefits, including reduced inflammation, improved joint lubrication, and cartilage repair. When cooked, chicken feet release bioavailable compounds that can positively impact RA symptoms, providing a cost-effective and accessible functional food, particularly in regions where they are culturally accepted and affordable. However, challenges such as allergenicity, cultural considerations, and variability in nutrient content require careful consideration. While preliminary research on collagen and glycosaminoglycans supports their role in joint health, direct studies on chicken feet for RA are limited, underscoring the need for further clinical trials. With appropriate sourcing and cautious integration, chicken feet could serve as a valuable dietary supplement, complementing traditional RA treatments and contributing to overall joint health and function.

References

1. Alivernini S, Firestein GS, McInnes IB. The pathogenesis of rheumatoid arthritis. Immu. 2022; 55: 2255-2270.
2. Yadav P, Kumar N, Lata K, Katri S, Kumar S. (n.d.). Rheumatoid arthritis: a comprehensive review of etiology, diagnosis, and therapeutic interventions.

3. Nikiphorou E, Philippou E. Nutrition and its role in prevention and management of rheumatoid arthritis. Autoimmunity Rev. 2023; 103333.
4. Zhou M, Sun Y, Luo L, Pan H, Zhang Q, Yu C. Road to a bite of rosehip: A comprehensive review of bioactive compounds, biological activities, and industrial applications of fruits. Trends Food Sci Technol. 2023; 136: 76-91.
5. Saini VP, Singh AK, Paul T, Thakur A, Singh M. (n.d.). Advances in environment management for sustainable fisheries & livestock production.
6. Sakunde DT. Extraction and characterization of collagen from poultry skin. Ind Veterinary Res Inst. 2020.
7. Tseng CC, Chen YJ, Chang WA, Tsai WC, Ou TT, Wu CC, et al. Dual role of chondrocytes in rheumatoid arthritis: the chicken and the egg. Inter J Molecular Sci. 2020; 21: 1071.
8. Kemp AD. The development of novel approaches to assess and improve skeletal integrity in laying hens. Nottingham Trent University (United Kingdom). 2021.
9. David Troncoso F, Alberto Sanchez D, Lujan Ferreira M. Production of plant proteases and new biotechnological applications: an updated review. Chemistry Open. 2022; 11: e202200017.
10. Prokopova A, Mokrejs P, Gal R, Pavlackova J, Hurajova A. Characterization of poultry gelatins prepared by a biotechnological method for targeted changes at the molecular level. Inter J Molecular Sci. 2024; 25: 916.
11. DePaoli ECRM. Evaluating perching biomechanics in commercial and random-bred strains of enriched-housed laying hens. 2023.
12. Jayaprakash S, Razeen ZMA, Kumar RN, He J, Milky MG, Renuka R, et al. Enriched characteristics of poultry collagen over other sources of collagen and its extraction methods: A review. Inter J Biol Macromolecules. 2024; 133004.
13. Martinez-Puig D, Costa-Larrion E, Rubio-Rodriguez N, Galvez-Martin P. Collagen supplementation for joint health: The link between composition and scientific knowledge. Nutrients. 2023; 15: 1332.
14. Dong F, Quan X, Wang Q, Liu Z, Cui T, Wang W, et al. Purification, structural characterization, and anticoagulant activity evaluation of chondroitin sulfate from codfish (Gadus macrocephalus) bones. Inter J Biol Macromolecules. 2022; 210: 759-767.
15. Golovach I, Rekalov D, Akimov Y, Kostenko H, Kostenko V, Mishchenko A, et al. Molecular mechanisms and potential applications of chondroitin sulphate in managing post-traumatic osteoarthritis. Reumatol. 2023; 61: 395.
16. Shen Q, Guo, Y, Wang K, Zhang C, Ma Y. A review of chondroitin sulfate's preparation, properties, functions, and applications. Molecules. 2023; 28: 7093.
17. Herrero-Beaumont G, Largo R. Glucosamine and O-GlcNAcylation: a novel immunometabolic therapeutic target for OA and chronic, low-grade systemic inflammation? In Annals of the rheumatic diseases. BMJ Pub Group Ltd. 2020; 79: 1261-1263.
18. Kaur G, Sharma A, Bhatnagar A. Role of oxidative stress in pathophysiology of rheumatoid arthritis: insights into NRF2-KEAP1 signalling. Autoimmunity. 2021; 54: 385-397.
19. Biji CA, Balde A, Nazeer RA. Anti-inflammatory peptide therapeutics and the role of Sulphur containing amino acids (cysteine and methionine) in inflammation suppression: A review. Inflammation Res. 2024; 73: 1203-1221.
20. Khan W, Shaukat R, Khan A, Khan A, Ahmad B, Saleem S, et al. Anti-inflammatory potential of aloe vera meatballs and their impact on rheumatoid arthritis. J King Saud University-Sci. 2024; 36: 103573.
21. Abourehab MAS, Baisakhiya S, Aggarwal A, Singh A, Abdelgawad MA, Deepak A, et al. Chondroitin sulfate-based composites: a tour d'horizon of their biomedical applications. J Materials Chem B. 2022; 10: 9125-9178.
22. Coscueta ER, Brassesco ME, Batista P, Borges S, Pintado M. Applications in medicine: joint health. In Biologically Active Peptides. Elsevier. 2021; 723-744.
23. Menezes R, Vincent R, Osorno L, Hu P, Arinzeh TL. Biomaterials and tissue engineering approaches using glycosaminoglycans for tissue repair: Lessons learned from the native extracellular matrix. Acta Biomaterialia. 2023; 163: 210-227.
24. Mukherjee A, Das B. The role of inflammatory mediators and matrix metalloproteinases (MMPs) in the progression of osteoarthritis. Biomat Biosys. 2024; 100090.
25. Mattiuzzo E, Faggian A, Venerando R, Benetti A, Belluzzi E, Abatangelo G, et al. In vitro effects of low doses of β-caryophyllene, ascorbic acid and d-glucosamine on human chondrocyte viability and inflammation. Pha. 2021; 14: 286.
26. Karila T, Tervahartiala T, Cohen B, Sorsa T. The collagenases: are they tractable targets for preventing cartilage destruction in osteoarthritis? Expert Opinion on Therapeutic Targets. 2022; 26: 93-105.
27. Ben MR, Bouchmaa N, Ainani H, El Fatimy R, Malka G, Mazini L. Anti-rheumatoid drugs advancements: New insights into the molecular treatment of rheumatoid arthritis. Biomedicine & Pharmacotherapy. 2022; 151: 113126.
28. Nunez FP, Quera R, Bay C, Castro F, Mezzano G. Drug-induced liver injury used in the treatment of inflammatory bowel disease. J Crohn's Colitis. 2022; 16: 1168-1176.
29. Davis JS, Ferreira D, Paige E, Gedye C, Boyle M. Infectious complications of biological and small molecule targeted immunomodulatory therapies. Cli Microbiol Rev. 2020; 33: 10-1128.
30. Magni A, Agostoni P, Bonezzi C, Massazza G, Mene P, Savarino V, et al. Management of osteoarthritis: expert opinion on NSAIDs. Pain Therapy. 2021; 10: 783-808.
31. Mueller AL, Brockmueller A, Kunnumakkara AB, Shakibaei M. Modulation of inflammation by plant-derived nutraceuticals in tendinitis. Nutrients. 2022; 14: 2030.
32. Romano G. Optimization of cooking for food service: matching quality and nutritional requirements as drivers for the development of innovative tools. 2023.
33. Kodous M. Physicochemical properties of hydrolyzed collagen produced from chicken feet. Middle East J Agr Res. 2020; 9: 81-89.
34. Al Hajj W, Salla M, Krayem M, Khaled S, Hassan HF, El Khatib S. Hydrolyzed collagen: Exploring its applications in the food and

beverage industries and assessing its impact on human health–A comprehensive review. Heliyon. 2024.

35. Batiha GES, Alqahtani A, Ojo OA, Shaheen HM, Wasef L, Elzeiny M, et al. Biological properties, bioactive constituents, and pharmacokinetics of some Capsicum spp. and capsaicinoids. Inter J Molecular Sci. 2020; 21: 5179.
36. Yu Z, Ke L, Lu T, Li L, Gu H, Rao P. Implementing a food first strategy can transform preventive healthcare. Npj Sci Food. 2024; 8: 57.
37. Abedi M, Shafiee M, Afshari F, Mohammadi H, Ghasemi Y. Collagen-based medical devices for regenerative medicine and tissue engineering. App Bioche Biotechnol. 2024; 196: 5563-5603.
38. Beasley S, Hiidenhovi J. The use of egg and egg compounds in companion animal health. 2024.
39. Omaliko PC. Dietary fat-induced perturbations in brain metabolite profiles influence fear response and gut neurotransmitter concentrations in chickens. North Carolina Agricultural and Technical State University. 2024.
40. Anchidin BG, Gucianu I, Lipsa FD, Ciobanu MM, Flocea EI, Boisteanu PC. From waste to valuable food: development and qualitative differential characterization of bone broths from juvenile and adult cattle. Scientific Papers. Series D. Animal Sci. 2024; 67.
41. Catalano A. Bone broth: from tradition to functional nutrition. 2022.
42. Jafari H, Lista A, Siekapen MM, Ghaffari-Bohlouli P, Nie L, Alimoradi H, et al. Fish collagen: Extraction, characterization, and applications for biomaterials engineering. Polymers. 2020; 12: 2230.
43. Xu R, Wu J, Zheng L, Zhao M. Undenatured type II collagen and its role in improving osteoarthritis. Ageing Res Rev. 2023; 91: 102080.
44. Haque MH, Sarker S, Islam MS, Islam MA, Karim MR, Kayesh MEH, et al. Sustainable antibiotic-free broiler meat production: Current trends, challenges, and possibilities in a developing country perspective. Biol. 2020; 9: 411.
45. Ferdaus MJ, Chukwu-Munsen E, Foguel A, da Silva RC. Taro roots: an underexploited root crop. Nutrients. 2023; 15: 3337.
46. Elango J, Zamora-Ledezma C, Ge B, Hou C, Pan Z, Bao B, et al. Paradoxical duel role of collagen in rheumatoid arthritis: Cause of inflammation and treatment. Bioeng. 2022; 9: 321.
47. Masson AO, Krawetz RJ. Understanding cartilage protection in OA and injury: a spectrum of possibilities. BMC Musculoskeletal Disorders. 2020; 21: 1-11.
48. Sun Y, Wang C, Gong C. Repairing effects of glucosamine sulfate in combination with etoricoxib on articular cartilages of patients with knee osteoarthritis. J Orth Surg Res. 2020; 15: 1-9.
49. Baca A. Impact of long-term collagen peptide supplementation in combination with physical training on recovery following exercise-induced muscle damage, body composition and musculotendinous adaptations. 2024.
50. Zhang H, Qi L, Shen Q, Wang R, Guo Y, Zhang C, et al. Comparative analysis of the bioactive compounds in chicken cartilage: protective effects of chondroitin sulfate and type II collagen peptides against osteoarthritis involve gut microbiota. Fro Nut. 2022; 9, 843360.
51. Hao L, Ma C, Li Z, Wang Y, Zhao X, Yu M, et al. Effects of type II collagen hydrolysates on osteoarthritis through the NF-κB, Wnt/β-catenin and MAPK pathways. Food Function. 2022; 13: 1192-1205.
52. Mohammed A, He S. A double-blind, randomized, placebo-controlled trial to evaluate the efficacy of a hydrolyzed chicken collagen type II supplement in alleviating joint discomfort. Nutrients. 2021; 13: 2454.
53. Yadav V, Krishnan A, Vohora D. A systematic review on Piper longum L.: Bridging traditional knowledge and pharmacological evidence for future translational research. J Ethnopharmacol. 2020; 247: 112255.
54. Fischer K. The healthy skin kitchen: for eczema, dermatitis, psoriasis, acne, allergies, hives, rosacea, red skin syndrome, cellulite, leaky gut, MCAS, salicylate sensitivity, histamine intolerance & more. Exisle Publishing. 2021.
55. Guide AP, Wendt J, Considine C, Kogan M. (n.d.). Integrative geriatric nutrition.
56. Carpenter KJ. Beriberi, white rice, and vitamin B: a disease, a cause, and a cure. Univ of California Press. 2023.
57. Maggiulli O, Rufo F, Johns SE, Wells JCK. Food taboos during pregnancy: meta-analysis on cross cultural differences suggests specific, diet-related pressures on childbirth among agriculturalists. Peer J. 2022; 10: e13633.
58. Shapiro P. Clean meat: how growing meat without animals will revolutionize dinner and the world. Simon and Schuster. 2024.
59. Goes EC. Evaluation of potential alternatives to replace antibiotic growth promoters in broiler chicken diets. 2024.
60. Hassoun A, Cropotova J, Trif M, Rusu AV, Bobis O, Nayik GA, et al. Consumer acceptance of new food trends resulting from the fourth industrial revolution technologies: A narrative review of literature and future perspectives. Fro Nut. 2022; 9: 972154.
61. Agostini D, Gervasi M, Ferrini F, Bartolacci A, Stranieri A, Piccoli G, et al. An integrated approach to skeletal muscle health in aging. Nutr. 2023; 15: 1802.
62. Augustin MA, Sanguansri L, Fox EM, Cobiac L, Cole MB. Recovery of wasted fruit and vegetables for improving sustainable diets. Trends Food Sci Technol. 2020; 95; 75-85.
63. Cao C, Xiao Z, Ge C, Wu Y. Animal by-products collagen and derived peptide, as important components of innovative sustainable food systems—A comprehensive review. Critical Rev Food Sci Nut. 2022; 62: 8703-8727.
64. Claudio-Rizo JA, Lopez-Badillo CM, Cruz-Ortiz BR. Hydrogel systems based on collagen and/or fibroin for biomedical applications. Handbook Res Bioenergy Biomaterials. Apple Academic Press. 2021; 529-572.
65. EFSA Panel on Nutrition, N. F. and F. A. (NDA), Turck D, Bohn T, Castenmiller J, de Henauw S, Hirsch-Ernst K, Knutsen HK, et al. Scientific opinion on the tolerable upper intake level for preformed vitamin A and β-carotene. EFSA J. 2024; 22: e8814.
66. Griffith JS. Chronic pain. Integrative and functional medical nutrition therapy: principles and practices. 2020; 447-471.
67. Hijjawi N, Tout FS, Azaizeh B, Aljaafreh B. The role of vitamins D, B12, C, and K in modulating inflammation and disease

management in rheumatoid arthritis: a comprehensive review. Cli Rheumatol. 2024; 1-10.

68. Larder CE. Simulated gastrointestinal digestion of collagen hydrolysates: assessment of peptide bioavailability, bioactivity and impact on gut microbial metabolites. McGill University (Canada). 2022.
69. Larder CE, Iskandar MM, Kubow S. Collagen hydrolysates: a source of bioactive peptides derived from food sources for the treatment of osteoarthritis. Med. 2023; 10: 50.
70. Li J, Cao J, Chen Q, Liu D, Li R. Investigating the therapeutic potential of sinomenine in rheumatoid arthritis: anti-inflammatory, antioxidant, and immunomodulatory mechanisms. Naunyn-Schmiedeberg's Arc Pha. 2024; 397: 3945-3958.
71. Malison A, Arpanutud P, Keeratipibul S. Chicken foot broth byproduct: A new source for highly effective peptide-calcium chelate. Food Che. 2021; 345: 128713.
72. Mendez Lopez LF, Gonzalez Llerena JL, Vazquez Rodriguez JA, Medellin Guerrero AB, Gonzalez Martinez BE, Solis Perez E, et al. Dietary modulation of the immune system. Nutrients. 2024; 16: 4363.
73. Pillai NS, Khan SA, Mehrotra N, Jadhav K. A comprehensive review on the role of collagen in health and disease. Biosci Biotech Res Asia. 2024; 21: 1329-1347.
74. Pritchard A. The role alterations in dietary calcium and silicon balance play on bone and cartilage in horses and poultry. Michigan State University. 2020
75. Simat V, Elabed N, Kulawik P, Ceylan Z, Jamroz E, Yazgan H, et al. Recent advances in marine-based nutraceuticals and their health benefits. Marine Drugs. 2020; 18: 627.
76. Staff U. Nutraceutical treatment in knee osteoarthritis—arthritis-presentation of a dietary plan by means of additional nutraceuticals in lieu of the detrimental side effects of current conventional medicine. Open J Orth. 2022; 12: 303-326.
77. Vlaicu PA, Untea AE, Oancea AG. Sustainable poultry feeding strategies for achieving zero hunger and enhancing food quality. Agr. 2024; 14: 1811.
78. Wang H. A review of the effects of collagen treatment in clinical studies. Polymers. 2021; 13: 3868.
79. Woods SL. Dietary means to improve antioxidant status in broiler chicken flocks. Harper Adams University. 2021.