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Therapeutic potential of curcuminoids in the treatment of selected autoimmune diseases

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Abstract

Introduction

The cause of autoimmune diseases is often unknown. Continuous research into the mechanism of these diseases allows us to discover new metabolic pathways, and thus new potential drugs that may become promising therapeutic tools in the future. Alternative methods of treatment are increasingly used when standard therapy does not bring the intended effects. One of the alternative methods of treatment is turmeric contained in Curcuma longa L.

Aim of the study

The aim of this article was to present the extremely promising potential of turmeric in the treatment of autoimmune diseases.

Materials and methods

The article is the result of a review of recent scientific literature using PubMed, Scopus and Google Scholar databases. The literature was reviewed using the keywords.

Results

In recent years, research on turmeric has accelerated significantly. Due to the insufficient effects of therapy achieved with standard methods of treatment, researchers want to find a new agent to fight serious diseases. Currently available medical literature has confirmed the beneficial effects of turmeric on inflammation in the body. The very mild side effect profile is also worth noting.

Conclusions

The anti-inflammatory effect obtained after the administration of appropriate doses of turmeric requires further research before it can be registered as one of the preparations for the treatment of autoimmune diseases. However, this topic is very interesting, and the substance itself is very interesting in the context of future disease therapy.

Key words

autoimmune diseases; curcumin; immunomodulatory effects; turmeric.

Introduction

Turmeric (Curcuma longa L.), also known as Indian turmeric or Indian saffron, belongs to the ginger family, Zingiberaceae. The hot, subtropical climate of India, China and Southeast Asia favors the cultivation of the plant. Turmeric is obtained from the rhizome - a yellow-orange, intensely colored powder, which has been used, among others, as a dye in the textile and food industry, a spice ingredient, found under the symbol E-100 added to mustards, bread, dairy products and canned fish. The turmeric rhizome is a source of many substances: curcuminoids, volatile oils, including: turmerone, germacron, zingiberene, elmenone, curlone, phellandrene, and resins. [1] There are three main curcuminoids in turmeric: curcumin, desmethoxycurcumin and bisdemethoxycurcumin, of which curcumin is the most important active ingredient. It is curcumin that gives turmeric its yellow color and is responsible for most of its therapeutic effects. [2] The healing properties of turmeric have been known in Asian countries for thousands of years, and the substance is still an important pillar of traditional Indian Ayurvedic medicine. The Chinese and Hindus used turmeric to treat liver and stomach diseases, indigestion, colic, and to relieve toothache. Today, turmeric paste poultices are still used to treat eye infections, wounds, bites, burns, acne, and other skin conditions. Turmeric is given with hot milk to treat coughs and respiratory problems, and is also used as an antipyretic in children. In some parts of India, women in childbirth are given an infusion of fresh turmeric paste, powdered ginger roots, and honey dissolved in milk to help the weakened body regenerate. [3]

Turmeric was brought to Europe in the 13th century, and five centuries later it gained the greatest recognition due to the unique taste and color it gave in spice mixtures. The curcumin molecule was first isolated from turmeric in 1815, and it was not until 1910 that Polish chemists determined its spatial structure. [1] In 1937, the first published article on the use of curcumin in treating human diseases mentioned its beneficial effects on the bile ducts. Since then, many studies have shown that curcumin can alleviate the course of many diseases. [4]

Curcumin is rapidly degraded by UV radiation and an alkaline environment. The bioavailability of orally administered curcumin is limited due to low absorption from the intestine and rapid degradation in the liver. As a result, the concentration of curcumin in plasma is low and reaches a peak 1-2 hours after ingestion. To increase the solubility of hydrophobic curcumin and its bioavailability, complexes with metal ions and albumins are used. The addition of piperine, nanoparticles, liposomes, phospholipids or the use of structurally modified curcumin analogues can also increase the absorption of the substance. In areas where turmeric is cultivated, turmeric consumption is common and high. In India, it can reach 2.0 to 2.5 g (corresponding to about 100 mg of curcumin). The oral lethal dose of curcumin has been estimated based on studies in mice (2-10 g/kg body weight) and rats (5-10 g/kg body weight). [1]

Pathomechanism of autoimmune diseases and targets of curcumin action

Autoimmune diseases result from an abnormal response of the immune system, which attacks its own cells and tissues. This abnormal response causes inflammation, cell damage, and dysfunction with accompanying symptoms. The part of the body that is targeted by the immune system (for example, a specific protein) is called an autoantigen or self-antigen, while the molecule that stimulates the immune response is called a foreign antigen. Autoimmune diseases can be acute or chronic. [5] Many autoimmune diseases are characterized by the production of autoantibodies, which bind to the host's own proteins or form immune complexes and are deposited in tissues. [6] Any organ, including the skin, joints, kidneys, and blood vessels, can be affected by autoimmunity as a result of the interaction of genetic and environmental factors that promote the development of autoimmunity, ultimately leading to inflammation and damage. [7] In autoimmune diseases, the balance between the body's recognition of foreign pathogens and the immune system's attack on self-antigens is disturbed, leading to abnormal immune tolerance. Type 1 interferons (IFN-1) produced by immune cells play a key role in systemic autoimmunity by activating B and T lymphocytes, while autoantibodies produced by B lymphocytes stimulate dendritic cells, which in turn produce IFN-1. Therefore, both the adaptive immune response pathway and the innate immune response pathway play an important role in the pathogenesis of systemic autoimmunity. [8] Studies have shown that systemic autoimmune diseases such as rheumatoid arthritis and systemic lupus erythematosus share common genetic loci (specific areas of chromosomes where genes are located) and have similar pathogenic mechanisms. Abnormal regulation of fundamental immune strategies such as the complement pathway, IFN synthesis, IFN response, and neuromodulatory mechanisms of the immune response contribute to autoimmunity and tissue damage.[7]

Adaptive immune cells also play an important role. With the activation of dendritic cells, interferon is produced in the autoimmune response, which promotes and maintains activated T cells and B cells in a vicious cycle and produces autoantibodies. Different cytokines activate naive T cells to promote their differentiation into helper T cells (Th cells) and regulatory T cells (Treg cells) through different transcription factors. Th cells and Treg cells secrete cytokines, which in turn activate different immune cells and coordinate immune effector mechanisms. There are also interactions between different subsets, creating complex mechanisms of regulation and action. [7] Curcumin has been shown to be a potent immunomodulator that can modulate the activity of T and B cells, macrophages, neutrophils, natural killer (NK) cells, and dendritic cells. [9] The diverse pharmacological effects of curcumin are due to its ability to interact with various biological targets and signaling pathways. The immunomodulatory activity of curcumin may involve direct activation of toll-like receptors (TLRs), such as TLR4 - the receptor for lipopolysaccharides (LPS) via pathogen-associated molecular patterns (PAMPs). The effects of curcumin also include regulation of various transcription factors, such as nuclear factor (NF-kB), activator protein 1 (AP-1), signal transducer and activator of transcription (STAT) and their downstream signaling pathways. In relation to the mechanisms of the innate immune response, curcumin inhibits the maturation of dendritic cells. Curcumin may reduce the recruitment of neutrophils to inflamed tissues by directly affecting neutrophil chemotaxis. [7] Studies have shown that this substance can also reduce the production of antibodies in the rat in response to LPS. [10,11] The immunomodulatory effects of curcumin on CD8+ and CD4+ T cell subsets may inhibit the production of Th1 cytokine profile in CD4+ T cells by inhibiting IL-12 (interleukin 12) production in macrophages. Curcumin-treated intestinal dendritic cells rendered intestinal T cells unresponsive. Furthermore, the antigen-presenting properties of curcumin-treated dendritic cells are blocked, resulting in reduced induction of the adaptive immune system. Curcumin also reduced the upregulation of proinflammatory cytokines, mainly IL-12, and inhibited Th1-type responses in dendritic cells. Furthermore, curcumin has been shown to reduce the expression of ICAM-1 (intercellular adhesion molecule-1) and CD11c, proteins involved in cell adhesion and T cell stimulation, probably via an AP-1-dependent pathway. [7]

The treatment of autoimmune diseases depends on the type and severity of the disease. Commonly used drugs include nonsteroidal anti-inflammatory drugs (NSAIDs), biologically targeted drugs, and traditional immunosuppressive drugs. However, these substances not only inhibit the autoimmune response, but also impair the body's ability to defend itself against infectious microorganisms and cancer cells. Therefore, the treatment of autoimmune diseases

is still an ongoing problem, and many researchers are increasingly interested in therapy with the adjuvant effects of natural products. [12]

Many in vitro and in vivo studies have shown that curcumin has various pharmacological effects, such as regulation of immune mechanisms, antioxidant effects, inhibition of inflammation, antitumor effects, antiangiogenic effects, and antithrombotic effects. These studies suggest that curcumin may play a regulatory role by changing the activity of enzymes, receptors, and related transcription factors. Numerous randomized controlled trials have shown that curcumin can alleviate the course of human diseases, including autoimmune diseases. Importantly, curcumin has very few side effects, making it a potential alternative to nonsteroidal anti-inflammatory drugs (NSAIDs) and other medications with known side effects.[13]

The use of curcumin in the treatment of rheumatoid arthritis

Rheumatoid arthritis (RA) is a chronic autoimmune disease characterized by persistent inflammation of the synovial membrane and hypertrophy of its lining layer leading to the formation of invasive joint pannus. The course of the disease leads to symmetric arthritis, degradation of joint cartilage and bone epiphysis, and the appearance of numerous extra-articular changes and systemic complications, including pulmonary fibrosis and vasculitis. The course of RA is chronic, with periods of exacerbations and remissions, and despite treatment, it leads to progressive joint destruction, varying degrees of disability, and premature death. The pathogenesis of RA is not fully understood; the role of genetic predisposition, environmental factors, previous infections, immunological disorders, and the action of reactive oxygen species is recognized. [14] In joints affected by RA, the presence of specific cells in the lining layer is observed, such as synoviocytes with a fibroblast phenotype (FLS), which are responsible for spatial organization, and macrophages (MfLS). Synoviocytes are a source of pro-inflammatory factors and enzymes that destroy connective tissue, and they also create an environment conducive to the infiltration of inflammatory cells. The formation of abnormal blood vessels, infiltration of adaptive and innate immune cells in the subcutaneous layer leads to hypoxia, inflammation and destructive processes. [15] Pro-inflammatory cytokines, such as TNF-α, IL-1β and IL-17, play an important role in the development of RA by influencing the inflammatory process. They stimulate catabolic processes in cartilage tissue and affect the progression of cartilage degradation. Particular attention is paid to IL-17 and cytokines responsible for the development of Th17 lymphocytes, such as IL-23 and IL-21, whose elevated levels correlate with disease activity. IL-17 not only participates in the production of Th17 lymphocytes, macrophages, mast cells and neutrophils, but also exhibits pro-destructive properties,

stimulating other cells to produce pro-inflammatory cytokines (e.g. IL-1β, IL-6 and IL-8, which are responsible for the inflammatory process) and matrix metalloproteinases (MMPs), which destroy the extracellular matrix of connective tissue. Disease activity and the degree of joint damage in patients are assessed using, among others, the clinical scale Disease Activity Score – 28 (DAS28), which assesses the number of swollen joints, the number of tender joints, ESR or CRP, and the patient's overall assessment of disease activity using the visual analogue scale VAS. [16]

Curcumin used in RA patients has a high ability to modulate inflammation by suppressing proinflammatory immune cell populations and inhibiting the production of inflammatory cytokines and chemokines. Studies have shown that this substance can reduce the expression levels of IL-6, IL-8, MCP-1, MMP-1, and MMP-3 proteins in FLS of RA patients. Several studies in animal models of RA have also confirmed this finding. Curcumin has also been found to inhibit the activation, proliferation, and differentiation of naive CD4+ T lymphocytes into Th 1 and Th 17 subtypes. These two cells play a key role in the pathogenesis of RA, producing key proinflammatory cytokines responsible for joint and bone destruction. In addition, curcumin has a strong ability to induce Treg differentiation and inhibit Th1 and Th17-mediated inflammatory responses. A 2023 meta-analysis showed that curcumin can reduce the DAS28 score. Lower values of inflammatory markers such as CRP, rheumatologic factor (RF), and erythrocyte sedimentation rate (ESR) were also observed in patients taking curcumin.[17] Additionally, curcumin selectively inhibits COX-2 in a dose- and time-dependent manner, which may prevent the biosynthesis of prostaglandin E2 (PGE2) from prostaglandin H2 (PGH2).[14]

The use of curcumin in the treatment of multiple sclerosis

Multiple sclerosis (MS) is an inflammatory, progressive demyelinating disease of the central nervous system (CNS). CNS changes are accompanied by clinical symptoms in the form of neurological deficit of varying severity, the constant or abrupt progression of which often leads to disability. [7] Damage to the myelin sheath of axons associated with the focus of inflammatory infiltration (demyelinating plaque) is an indicator of the ongoing pathological process in the brain and spinal cord. The key processes in the pathogenesis of MS are the activation of immune cells, the secretion of inflammatory cytokines, and the differentiation of Th1 cells. [18] The most well-known and widely used disability assessment scale for MS is the Expanded Disability Status Scale (EDSS), which is based on the presence of symptoms in a typical neurological examination (0 – normal neurological examination, 5 – patient able to walk

without assistance and rest for about 200 meters, 9 – patient lying helpless, able to communicate and eat). [19]

Two randomized controlled clinical trials have evaluated the effect and safety of curcumin in the treatment of MS. Both studies showed that curcumin can reduce the release of inflammatory factors, but the results differed in terms of improving EDSS. However, because the data could not be combined for meta-analysis, they should be interpreted with caution. Experimental autoimmune encephalomyelitis (EAE) is a well-established animal model for studying the mechanisms of demyelination and neurodegeneration occurring in MS. In these models, curcumin has been shown to have a protective effect on EAE in rats and it has been found that 50-100 mg of curcumin administered by gavage every other day can alleviate EAE symptoms. In addition, curcumin can inhibit Th1 differentiation and TNF-γ production. It has been found that curcumin can significantly improve the clinical symptoms of rats with EAE, inhibit inflammatory cell infiltration in the spinal cord, and promote recovery of rats, thereby treating MS. Treatment was also associated with upregulation of anti-inflammatory IL-10 levels and increased percentages of CD4+CD25+-Foxp3+ Treg cells in the central nervous system and lymphoid organs of mice, which play an important role in maintaining immune tolerance. Furthermore, curcumin ameliorated EAE in mice by inhibiting IL-12 signaling through the JAK-STAT pathway (an intracellular protein system used by multiple cytokines and growth factors to express genes that mediate cell activation, proliferation, and differentiation), resulting in reduced Th1 differentiation. In vivo, curcumin treatment has been shown to increase the expression of immunoregulatory peroxisome proliferator-activated receptor-γ in the central nervous system and lymphoid organs of EAE mice, suggesting that it is involved in the regulation of Th1/Th17 responses in EAE. In a study on MS patients, it was shown that curcumin could inhibit the mRNA expression of IL-17 and INF-γ levels of T cells. All these experimental results suggest that curcumin can be used in the treatment of multiple sclerosis, therefore, clinical trials are needed to further verify the therapeutic effect and safety of curcumin in the mentioned application. [7]

The use of curcumin in the treatment of ankylosing spondylitis

Ankylosing spondylitis (AS) is a disease characterized by inflammation of the sacroiliac joints, spinal joints, fibrous rings, and spinal ligaments, which leads to their gradual stiffening. It often begins in late adolescence or young adulthood, and the course is chronic and progressive. In addition to changes in the musculoskeletal system, there is also inflammation of the anterior uvea, pulmonary fibrosis, and changes in the circulatory system. The main symptoms of AS are periodic pain in the lumbosacral region, discomfort, and

stiffness in other parts of the body, which ultimately lead to immobility and stiffness of the spine.

Recent studies have shown that T lymphocytes play an important role in the pathogenesis of AS, as evidenced by changes in the frequency of CD4+ T lymphocytes in the peripheral blood of patients with AS. There is an increase in the frequency of proinflammatory Th17 versus Th2 and a decrease in anti-inflammatory CD4+ CD25+ Tregs. Most studies suggest that the Treg/Th17 ratio is reduced in patients with AS. It is speculated that altered immunophenotypes may play a role in the pathogenesis of this disease, and therefore modulation of the balance between Tregs and Th17 may contribute to the reduction of disease activity. [7,20]

One randomized clinical trial evaluated the effect and safety of curcumin and turmeric extract in the treatment of AS. An increase in the population of Tregs, an increase in the levels of anti-inflammatory IL-10 and TGF-b, and a decrease in pro-inflammatory IL-6 were demonstrated after curcumin administration. Recent studies have shown that curcumin can enhance Treg differentiation by increasing the expression of FoxP3. However, more clinical trials are still needed to verify the therapeutic effect and safety of curcumin in AS.[7]

The use of curcumin in the treatment of systemic lupus erythematosus

Systemic lupus erythematosus (SLE) is an autoimmune disease with an extremely diverse course, affecting many tissues and organs. Chronic inflammation develops, among others, in the skin (acute and subacute cutaneous form of lupus erythematosus, discoid lupus), blood vessels, joints, kidneys (lupus nephropathy), respiratory system, circulatory system or nervous system (neuropsychiatric lupus). Disease activity is assessed using, among others, clinical symptoms, laboratory indicators (blood count, proteinuria, concentrations of complement C3 and C4 components, anti-dsDNA titer in serum) and indicators of general disease activity – e.g. the SLEDAI scale (Systemic Lupus Erythematosus Disease Activity), which takes into account symptoms observed within 10 days before the visit to a rheumatologist. [21,22]

Two randomized clinical trials analyzed the effect and safety of curcumin and turmeric extract in the treatment of SLE. One of them included 24 patients with lupus nephritis and no adverse events related to curcumin supplementation were observed during the study. Another introduced a 60 mg curcumin preparation in combination with cholecalciferol (vitamin D3) as a treatment regimen in the study group, which included a total of 40 subjects. It was found that the improvement in SLEDAI, decrease in IL-6 and decrease in TGF-b1 by 60 mg curcumin in

combination with cholecalciferol were not statistically different from the control group (P>0.05). [7]

The use of curcumin in the treatment of psoriasis

Psoriasis is a chronic, multifactorial, genetically based inflammatory disease. It is characterized by specific skin lesions resulting from excessive keratinization of the epidermis, which is the result of uncontrolled proliferation of keratinocytes. [23] The disease is often not limited to the skin. It can affect the joints, thus leading to disability and – due to the development of a metabolic syndrome – contribute to the patient's death. This condition has a significant impact not only on the health, but also on the quality of life of the patient - research results confirm an increased risk of suicidal thoughts and behaviors in the case of psoriasis. [24] The incidence of psoriasis in the general population is relatively high, and the incidence in European and American countries is about 2.1%. [7] To assess the severity of the disease and the effectiveness of treatment, the following methods are used: PASI scale (Psoriaris Area and Severity Index), defining erythema, thickness of lesions and scale build-up and the affected surface area in 4 locations – head, trunk, upper limbs, lower limbs. [25] It is currently widely believed that the cause of psoriasis is an immune imbalance caused by external stimuli such as infection, trauma, mental stress and other factors influenced by the patient's genetic predisposition. The role of immune mechanisms in the pathogenesis of psoriasis has been widely accepted, and it has also been shown that most susceptibility genes are associated with the functioning of immunity. The immunological pathomechanism of psoriasis is complex. It involves keratinocytes and various immune cells, including dendritic cells, macrophages, neutrophils and T lymphocytes in innate and acquired immunity. It is believed that in psoriasis, loss of immunotolerance causes the formation of autoreactive Th1 and Th17 lymphocytes. These cells recognize autoantigens, leading to destruction. Activation of the IL-12/Th1/IFN-γ and Th17/IL-23 axes plays an important role in the disease. The mechanism is probably based on the action of key interleukins: IL-12 affects naive T lymphocytes and Th1 lymphocytes, and IL-23 sustains the inflammatory response mediated by Th1, stimulates the maturation and activity of Th17, and maintains the pool of memory cells. IFN-γ, produced mainly by Th1 lymphocytes, plays an important role in the autoimmune processes occurring in the course of the disease.

In psoriasis, the function of Treg lymphocytes, which are responsible for eliminating autoreactive lymphocytes, is also impaired. Moreover, psoriatic keratinocytes are less susceptible to apoptosis. Both the adaptive and innate immune systems can mediate the production of inflammatory mediators, and the latter play an important role in inducing and

maintaining the pathological changes of cutaneous and epidermal psoriasis.[26] Currently, various topical and systemic treatment options are available for the treatment of psoriasis, but they have suboptimal clinical outcomes and the risk of adverse events.

Many recent studies have shown that curcumin can reduce oxidative stress in psoriatic lesions. Moreover, the therapeutic efficacy of curcumin may also be related to its ability to inhibit phosphorylase kinase (PhK), the increase of which is correlated with the severity of disease symptoms. Curcumin can inhibit cell proliferation by reducing the levels of pro-inflammatory factors such as IL-17, TNF-α, INF-γ, and IL-6. [27] Furthermore, curcumin significantly improved the skin barrier function by upregulating involucrin (iNV) and filaggrin (FLG), which form a compact, resistant stratum corneum, constituting the architectural framework of the so-called epidermal barrier. [28] In animal studies, daily application of 1% curcumin gel reduced psoriasis-like skin inflammation artificially induced by imiquimod. Curcumin has also been shown to inhibit the proliferative effects of vascular endothelial growth factor (VEGF) on the HaCaT cell line, a model of human keratinocytes, and to promote apoptosis of these cells. Two randomized, controlled trials showed that curcumin improved PASI scores in patients with psoriasis without increasing side effects compared with the control group.[7] Daily use of turmeric tonic significantly reduced skin symptoms and quality of life in patients with scalp psoriasis compared with placebo.[23] Furthermore, in another study, curcumin treatment enhanced the antipsoriatic effects of topical steroids when used in combination therapy.[29]

Curcumin Safety Profile

Curcumin is considered a safe compound by the European Medicines Agency (EMA) and the US Food and Drug Administration (FDA). Numerous preclinical and clinical studies have assessed the safety of this compound. The maximum recommended daily dose is 3 mg/kg bw. up to 4–10 g. [30] In clinical studies, where adverse events were reported, the following were noted: mild gastrointestinal disturbances (dyspepsia, flatulence and gastroesophageal reflux, nausea and vomiting, edema, loose stools, constipation, increased frequency of bowel movements and hot flashes. In a clinical study, curcumin was not detectable in the serum of healthy individuals who were given up to 8,000 mg per day, while low levels were observed at a dose of 10,000 or 12,000 mg per day. No harmful effects were observed in any of the subjects, considering a daily intake of 12,000 mg as safe for healthy individuals. A good safety profile of curcumin was also observed in patients with cardiovascular risk factors and in patients with pre-cancerous lesions of internal organs taking a dose of curcumin from 500 to 8,000 mg/day for 3 months. This safety was also observed in patients with advanced colorectal cancer taking

curcumin at a dose of 36 to 180 mg/day for up to 4 months, in breast cancer patients undergoing radiotherapy with curcumin up to 6,000 mg/day, and in patients with advanced pancreatic cancer taking curcumin at a dose of 8,000 mg/day for 2 months. Other studies, in both healthy individuals and patients with diseases such as advanced colon cancer, cholangitis, and ulcerative colitis, have shown mild and manageable gastrointestinal symptoms with daily intakes of up to 8,000 mg of curcumin. Short-term intravenous administration of liposomal curcumin (particles encapsulated in phospholipids) has been shown to be safe up to a dose of 120 mg/m2 in a clinical trial in healthy subjects, whereas in a dose-escalation study in patients with metastatic cancer, a dose of 300 mg/m2 over 6 hours was found to be the maximum tolerated dose. Changes in red blood cell morphology observed during this therapy may be a sign of liposomal curcumin toxicity – one case of hemolysis and one death associated with intravenous curcumin administration were reported in studies, suggesting the need for caution and further data on the safety and recommended doses of intravenous curcumin. [23]

It is worth noting that most of the studies to date evaluating the safety profile of curcumin have been conducted in the short term. There is a lack of reliable evidence on the effects of long-term use of this compound. Although the recommended doses of over-the-counter curcumin are usually lower than those used in the clinical trials mentioned earlier, supplements containing this compound are widely available and are becoming increasingly popular. Numerous curcumin preparations are available on the Internet, but these supplements, unlike drugs, are not subject to strict controls and may be potentially harmful.

Recent reports of possible liver diseases associated with curcumin intake have drawn attention to the potential hepatotoxicity of this substance. The exact role of curcumin in the development of these diseases is still unclear, and there has been speculation about the possibility of lead contamination of supplements. Until further data is collected, vigilance is necessary, especially in the case of long-term use, in the context of over-the-counter supplements and in patients with liver disease. [31-32]

Summary

The interest in the healing properties of naturally derived substances is constantly growing, and curcumin is becoming a widely known and available dietary supplement. The above work presents the results of randomized controlled clinical trials that confirm the beneficial effects of curcumin in the treatment of autoimmune diseases: rheumatoid arthritis, multiple sclerosis, ankylosing spondylitis and psoriasis with a minimal number of adverse effects. However, no significant improvement compared to placebo has been observed in the treatment of systemic lupus erythematosus. In recent years, a multitude of targets have been

discovered on which curcumin has a beneficial effect: it modulates various biological targets, including transcription factors, growth factors, inflammatory mediators, cytokines, cell cycle proteins, enzymes, protein kinases and apoptotic proteins, as well as entire cellular pathways. All these factors are of significant importance in the pathogenesis of autoimmune diseases in which immune tolerance is disturbed. The results of the studies conducted to date, presenting the beneficial properties of this substance, are optimistic and indicate the need for further treatment trials involving curcumin.

Disclosure

Authors contributions

Joanna Cieszkowska: Conceptualization, Writing - rough preparation, Methodology, Investigation, Project administration

Karina Otręba: Formal Analysis, Visualisation

Karolina Czupryńska: Software, Writing – review and editing.

Piotr Daniel: Methodology, Investigation

Michał Leśkiewicz: Supervision, Resources

Justyna Aleksandra Składanek: Supervision, Data curation

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Conflict of Interest Statement

All authors declare that they have no conflicts of interest.

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