Ad-Dawaa' Journal of Pharmaceutical Sciences
ISSN: 2654-7392, E-ISSN: 2654-6973
Vol. 5, No. 2, December 2022, Hal. 79 – 93
DOI: https://doi.org/10.24252/djps.v5i2.29539

Nano Curcumin - The Little One with The Big Impact : A Review

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ABSTRACT

Curcumin is a compound contained in Curcuma longa, and this compound has many health benefits. One of the problems of this compound is its poor bioavailability, but methods to solve this problem have been found. One way to overcome the problem of curcumin bioavailability is to make curcumin in nano dosage forms. This article discusses the potential of curcumin nano as a future therapy for various diseases. We take a variety of sources by considering the source based on the index owned by the source. Scopus, Web of Science and Sinta are our main parameters. Articles not indexed by all three indexers are included in our rating. In conclusion, we found that curcumin in nano form has a very good potential to be used as a future therapy. However, further research is still needed to see the side effects of nano curcumin if used in the long term.

***KEYWORDS**:* Curcumin, health, herb, medicin, nano

INTRODUCTION

Curcumin is a compound contained in Curcuma longa, and this compound has many health benefits. One of the problems of this compound is its poor bioavailability, but methods to solve this problem have been found. One method of solving the problem of curcumin bioavailability is to make curcumin in nano dosage forms. This article discusses the potential of nano curcumin as a future therapy for various diseases. We take various sources by considering the source's credibility based on the index owned by the source. Scopus and Web of Science are our main parameters. Articles not indexed by both indexers are included in our exclusion criteria. In conclusion, we found that curcumin in nano form has excellent potential to be used as a future therapy. However, further research is still needed to see the side effects of nano curcumin if used in the long term (Karthikeyan et al., 2020).

Curcumin, which is a polyphenol, is able to target several signalling molecules, which is one factor that contributes to its myriad

positive health effects. It has been shown that its use is beneficial for the treatment of pain as well as a variety of inflammatory, metabolic, and degenerative eye disorders. In addition to this, there is evidence that it has a beneficial effect on renal function. The majority of the curative effects that may be gained by taking curcumin in supplement form can be credited to the antioxidant and anti-inflammatory characteristics that it has. Despite the fact that curcumin has been demonstrated to have anti-inflammatory and antioxidant properties, ingestion of the compound on its own results in a low bioavailability owing to its poor absorption, fast metabolism, and rapid elimination. This is a serious problem with the consumption of curcumin. The bioavailability of curcumin has been increased thanks to the efforts of a number of drugs that target these pathways. (Hewlings & Kalman, 2017).

One of the most significant limitations of curcumin is that it has a poor oral bioavailability (approximately 1% in rats), which severely restricts its possible applications. Curcumin has a solubility in an aqueous buffer with a pH of 5 that may reach a maximum of 11 ng/ml, however it is only marginally absorbed through the gastrointestinal system. It is possible to increase the bioavailability of this drug by using substances like piperine, liposomes, nanoparticles, and phospholipids or by modifying the structure of curcumin analogues. Improved bioavailability, reduced curcumin degradation during metabolism, and increased delivery capacity to tumours are three critical goals that could remove curcumin usage restrictions. There are a variety of different nanoparticle adjuvants that can be used to deliver curcumin to cancer cells. These include solid lipid nanoparticles (such as liposomes) and polymer nanoparticles (such as polymeric micelles) (Rahimi et al., 2016).

This article explores the prospect of using nano curcumin in the future as a treatment for various health issues prevalent in the modern world. This article is a compilation of different researches that have been carried out and published, which we have taken from various sources.

MATERIAL AND METHODS

Reference Sources

The websites of several trustworthy publishers that provide clear guidelines serve as the sources from which we receive the reference materials that we employ. When we talk about parameters, what we mean is that each paper has been indexed by either Scopus, the web of science, or Sinta for local journals.

Inclusion Criteria

All sources we use must be indexed in Scopus, Web of Science, or Sinta for local journals. They must specifically discuss curcumin nanoparticles and their applications in treating a wide range of diseases.

Exclusion Criteria

Our criterion for omitting papers also included those that were not indexed by Scopus, Web of Science, or Sinta. This meant that we did not include publications that had been published in predatory journals.

RESULTS AND DISCUSSION

Anti-inflammatory

Inflammation is one of the most common health issues that a large number of individuals struggle with. Inflammation is a result of the activation of the immune system, which may be activated in response to a broad number of stimuli. This activation of the immune system is what causes inflammation to develop. The immune system is a defense mechanism that is very complicated and has been improved via evolutionary processes. It has both cellular and humoral components in its make-up (Sahlmann & Ströbel, 2016).

It is generally agreed upon that inflammation and oxidative stress are important pathophysiological elements in the development and clinical presentation of metabolic syndrome. This notion has gained widespread acceptance in recent years. Curcumin, which is a polyphenolic molecule isolated from turmeric, has been proven to possess anti-oxidant as well as anti-inflammatory characteristics. In order to determine whether or not curcumin nano-micelles had any impact on oxidative stress, systemic inflammation, adiponectin, or nuclear factor-kB levels, a research was conducted on individuals diagnosed with MetS. (NF-kB). In a clinical study that was conducted using a randomized, double-blind design, patients who were diagnosed with metabolic syndrome were given either 80 mg/day of nano-curcumin or a placebo. This research found that there was an increase in adiponectin as well as malondialdehyde and the overall antioxidant capacity of curcumin. It was shown that a 12-week supplementation with 80 mg/day of nano-micelle curcumin might boost malondialdehyde, Total antioxidant capacity, and adiponectin; however, no significant effects on hs-CRP and NF-B were seen among or between the different groups of individuals (Bateni et al., 2022).

An experiment with two sets of blinding was carried out at the Akbar Children's Hospital in Mashhad. Children who were diagnosed with cystic fibrosis were included in the study. A placebo along with 80 milligrams of curcumin will be administered every day for the next three months. Interleukin-6, interleukin-10, high-sensitivity C-reactive protein, faecal calprotectin, and nasopharyngeal neutrophil counts were used to measure inflammation as the main endpoint of this study. A supplementary set of objectives includes spirometry, anthropometry, and quality of life measures. The patients were reassessed after a period of three months. The findings of the investigation were favorable. CFTR is a

cAMP-activated Cl ion channel that is located in the apical membrane of epithelial cells. It is a curcumin target that has been investigated extensively (Talebi et al., 2021).

Nano curcumin has anti-inflammatory potential in COVID-19 patients and offers promise as a treatment. Patients diagnosed with COVID-19 had substantially elevated levels of mRNA expression and cytokine production of IL-1, IL-6, TNF-, and IL-18 as compared to the healthy controls. After treatment with Nano-curcumin, there was a statistically significant reduction in the levels of IL-1 gene expression and secretion in the serum and supernatant. Additionally, there was a statistically significant reduction in the levels of IL-6 expression and secretion in the serum. The expression of IL-18 mRNA as well as TNF- levels were unaffected by nano-curcumin. To put things another way (Valizadeh et al., 2020).

Additionally, Iran conducted research on nano curcumin in COVID-19 patients. 60 individuals in the COVID-19 study were given nano-curcumin at a dosage of 240 milligrams per day for seven days. Clinical and analytical data were recorded on day 0 and day seven of the experiment. The mRNA expression of IFN-, IL-1, IL-6, MCP-1, and TNF- was measured using real-time SYBR Green PCR and ELISA, and blood levels of IL-1, IL-6, and TNF- mediators were measured using ELISA. The therapy with nano-curcumin improved clinical and laboratory parameters while simultaneously decreasing IFN- and TNF- mRNA levels. The expression of IFN-, IL-1, and IL-6 was distinct between the nano-curcumin group and the control group. Serum IL-1 levels were substantially different between the nano-curcumin group and the control group. It's possible that nano-curcumin has anti-inflammatory properties and might help reduce inflammatory problems (Asadirad et al., 2022).

Anti-Bacterial

Molecular activity that inhibits bacterial and viral growth or kills them locally is closely linked to compounds that are not toxic to nearby tissues but kill or slow the growth of bacteria and viruses locally. Many of the most recently discovered antimicrobial agents, such as penicillins, carbapenems, and cephalosporins, are derived from naturally occurring compounds that have undergone chemical modification. Aminoglycosides and other synthetic antibiotics like sulfonamides and pure natural antibiotics like aminoglycosides are frequently used (K. Singh et al., 2019).

Curcumin was encapsulated in nanocapsules of poly(lactic-co-glycolic acid) and Pluronic F68 (poloxamer 188) and tested against Gram-negative bacteria (*E. coli, Salmonella typhimurium, and P. aeruginosa*) and Gram-positive bacteria (*S. aureus, Bacillus sonorensis, and Bacillus licheniformis*). Curcumin in nanocapsules showed greater efficacy than free curcumin

against all tested species due to lower MIC values (75 and 100 g/mL) (Curcumin in DMSO and distilled water). The MIC values for free curcumin varied from 100 to 300 g/mL, which explains why. The minimum inhibitory concentration (MIC) for curcumin in nanocapsules against Gram-positive and Gram-negative bacteria was determined to be 75 and 100 g/mL, respectively (Trigo-Gutierrez et al., 2021).

Wet milling was used to produce nanoparticles of nanocurcumin, also known as nano curcumin. According to the findings of the investigation, the particle dispersion of these things ranged from 2 to 40 nm. Curcumin is a surfactant-bound compound; nano curcumin, on the other hand, was found to be free-floating in air. Nanocurcumin's chemical structure is identical to curcumin's, and nanoparticle production does not alter this. Nanocurcumin was tested against Curcumin to see which had lower minimum inhibitory concentrations for various bacterial and fungal strains. Nanocurcumin has the ability to stop the growth of many different kinds of microorganisms, such as *S. aureus*, a bacterium that is known to cause skin disorders; *Bacillus subtilis*, a bacterium that is known to cause problems in the digestive tract; *P. aeruginosa*, a bacteria that is known to cause nosocomial pneumonia; and *Aspergillus niger*, a fung When compared to curcumin on its own, nanocurcumin demonstrates superior activity against the aforementioned pathogens. According to the findings, Curcumin's antibacterial action is known to be improved by nanoparticles. (Bhawana et al., 2011).

Neuroprotective

To achieve neuroprotection, a therapy must be able to interfere with and inhibit the pathogenetic cascade that leads to cell dysfunction and eventual death in order to prevent the death of neurons(Schapira, 2010). Using 6-hydroxydopamine (6-OHDA) decreased cell survival, while nanocurcumin at 400 and 500 nM protected the cells against apoptosis and death. The decrease in p-Akt/t-Akt caused by 6-hydroxydopamine may be prevented and even reversed with this nanoformulation of curcumin (6-OHDA). The MTT results demonstrate that BSA-based nanocurcumin has a protective effect that is at least four times greater than that of natural curcumin. One colorimetric method for gauging cellular metabolic activity is the MTT assay (Sookhaklari et al., 2019).

Excessive production of reactive oxygen species is caused by mitochondrial dysfunction during cerebral ischemia-reperfusion, and this accelerates the progression of neurodegeneration. The antioxidant properties of curcumin protect against the oxidative damage that may be produced by ischemia and reperfusion of the brain. Only very large dosages of free curcumin are useful since the compound has a poor bioavailability. In addition, the blood-brain barrier prevents chemicals already

present in the circulatory system from entering the brain. Curcumin encapsulated in polyethylene glycolated nanoparticles was orally administered to aged rats to determine its role in protecting against brain damage after ischemia and reperfusion. It was investigated to see whether there was any damage to the mitochondria. An analysis was done on cytokines that promote inflammation as well as components of the apoptotic pathway. When compared to Free curcumin, pre-treatment with nanoparticles offered superior neuroprotection. To do this, we reduced the oxidative damage caused by reactive oxygen species and prevented the neuronal apoptosis caused by cerebral ischemia-reperfusion. Therefore, it is possible to deliver curcumin to the brain in the form of curcumin-incorporated polyethylene glycolylated polylactide-co-glycolidenanoparticles, which can increase the bioavailability of curcumin and may protect neurons from the oxidative damage caused by cerebral ischemia-reperfusion (Mukherjee et al., 2019).

Following subarachnoid hemorrhage, nano-curcumin upregulates the glutamate transporter-1, which reduces glutamate concentrations in cerebro spinal fluid and inhibits the activation of microglia (Zhang et al., 2017). When curcumin is delivered to the brain in the form of nanostructured lipid carriers, there is a strong correlation between the formation of nanostructured carriers, lipid peroxidation, and the adenosine diphosphate/adenosine diphosphate ratio in the hippocampal tissue and improved spatial memory. This is because the formation of nanostructured carriers is directly correlated with lipid peroxidation (nanostructured lipids). Research conducted on animal models of Alzheimer's disease shown, among other things, that curcumin-nanostructured lipid carriers had the potential to lessen the presence of amyloid. In a study that investigated the neuroprotective potential of curcumin-nanostructured lipid carriers, the researchers found evidence that loading curcumin into nanostructured lipid carriers is an effective strategy for increasing curcumin delivery to the brain and reducing amyloid-induced neurologic abnormalities and memory defects. These findings could serve as the basis for future research into Alzheimer's prevention and treatment options (Sadegh Malvajerd et al., 2019).

There was an increase in oxidative stress, inflammation, cell death, and oxidative DNA damage in the brains of mice that were administered Copper, Nano-Curcumin, and Curcumin. Copper, which is a redox active metal, may be found in a variety of organs and tissues. The AKT/GSK-3 signaling pathway is at least partially responsible for the neuroprotective benefits that Nano-Curcumin and Curcumin have against the neurotoxicity caused by Copper. Nano-Curcumin has a more potent neuroprotective impact than the conventional version, which may contribute to an increase in the health

benefits already associated with curcumin (Hasan, 2021).

Anti-hyperlipidemia

One of the most prominent risk factors that leads to the development of atherosclerosis and, as a direct result of this, vascular disease is hyperlipidemia, and more specifically, increased LDL cholesterol (hypercholesterolemia). To express it in the most basic words imaginable, it is feasible to characterize it as an unusually high concentration of lipids or fats in the blood. This is one way to think about it (Chen et al., 2014).

Nanocurcumin formulations were used in preventative investigations in hyperlipidemic rats. For the experiment, we divided 49 male Wistar rats into 7 different groups. Standard control, negative control, 80 milligrams per kilogram of body weight per day curcumin control, curcumin nanosuspension, and curcumin nanoemulsion were the groups studied. Curcumin, solid lipid nanoparticles, 80 mg/kg body weight once day. Oil and water nanoemulsions are created when SNEDDS interact with stomach acid. There is a possible 67-day window in which you will be safe from harm. Start on day 11 and for the following 67 days, feed 2mL of lard and egg yolk per 200g of body weight (1:1). Biotin-Streptavidin-Amplified Enzyme-Linked Immuno-sorbent Assay was used to evaluate VCAM-1 and IL-6 levels on day 68. Compared to curcumin suspension, nanocurcumin at 80mg/kg BW significantly increased the preventative activity of curcumin by decreasing VCAM-1 in SNEDDS (53.26%), nanoemulsions (52.73%), nanosuspension (52.325%), and solid lipid nanoparticles (51.444%) (Pradana et al., 2019).

VCAM-1, or vascular cell adhesion molecule-1, is a cell surface adhesion protein that recruits leukocytes to endothelial cells on artery walls and has a role in the development of atherosclerosis (Iademarco et al., 1992). Interleukin-6 is a cytokine that is secreted from body tissues into the blood plasma, particularly during the acute or chronic phase of an infection. It is responsible for inducing a transcriptional inflammatory response via the RA IL-6 receptor, in addition to inducing B cell maturation and gp130 absorption (Tanaka et al., 2014).

The addition of nano-curcumin to the diet led to an improvement in HDL levels. A decrease in total cholesterol, triacylglycerol, and low-density lipoprotein cholesterol was seen after administration of this drug, suggesting a hypolipidemic action. Patients with dyslipidemia (classified as TG > 150 mg/dL, TC > 200 mg/dL, and LDL cholesterol > 100 mg/dL) were used to show the impact. The results also showed that CRP, IL-6, and systolic blood pressure levels were dropped, which is consistent with the anti-inflammatory and hypotensive effects that nano-curcumin supplementation may have (Ashtary-Larky et al., 2021).

Anti-Diabetes

Defects in insulin production, action, or both lead to the persistent hyperglycemia that characterizes diabetes mellitus. Because of insulin's anabolic actions, metabolic anomalies in carbohydrate, lipid, and protein metabolism occur. Metabolic disorders are brought on by a lack of insulin or insulin resistance in the body's target tissues, most notably skeletal muscles, adipose tissue, and to a lesser degree the liver, due to changes in the insulin receptors, signal transduction system, and/or effector enzymes or genes. The intensity of symptoms varies depending on the kind and duration of diabetes. Patients with type 2 diabetes in the early stages of the illness are more likely to have no symptoms at all. Polyuria, polydipsia, polyphagia, weight loss, and hazy eyesight are symptoms that may affect others, particularly children with absolute insulin insufficiency. When left untreated, diabetes may lead to ketoacidosis or nonketotic hyperosmolar syndrome, both of which can induce coma and even death if not treated (American Diabetes Association, 2014; Galtier, 2010).

There were 80 diabetes individuals who took part in the double-blind, placebo-controlled research. randomly assigning subjects to either the intervention or the control group (n = 40). Nano-curcumin 80 mg or placebo for eight weeks. Analyses of DSP severity, glycemic index, anthropometrics, diet, and exercise were conducted before and after the intervention. Micro curcumin reduces both hemoglobin A1c and fasting glucose levels (Asadi et al., 2019).

Curcumin (as nano-micelles 80 mg/d) or a placebo was administered to people with type 2 diabetes (fasting blood glucose (FBG) 126 or 2-hour postprandial blood glucose (BP) 200 mg/dL) for three months. based on data from a randomized, double-blind trial We compared pre- and post-intervention levels of glucose, hemoglobin A1c, and lipids. There were no significant baseline differences in age, BMI, RBG, total cholesterol, triglycerides, LDL, HDL, HbA1c, or gender. The subjects in the Nano-curcumin group had decreased HbA1c, fasting blood glucose, total cholesterol, and body mass index both before and after therapy (Rahimi et al., 2016).

To test the effects of curcumin and nano-curcumin, 48 male Wistar rats were split into six groups: control, diabetes, 100 mg/kg curcumin, 200 mg/kg curcumin, and 100 mg/kg nano-curcumin. Niacinamide (110 mg/kg) and streptozotocin (45 mg/kg) were used to develop type 2 diabetes in fasted animals. Mice were orally administered curcumin and nano-curcumin for 28 days. After the treatment, the subjects' levels of insulin resistance, fasting blood sugar, apelin, and lipids were all taken. Curcumin and nano-curcumin dramatically improved insulin sensitivity and decreased insulin resistance, as well as blood levels of FBS, Apelin, cholesterol, triglycerides, LDL, and VLDL, in diabetic rats. Compared to the

curcumin and diabetic groups, the HDL values were highest in the nano-curcumin group. Serum levels of applein increased along with insulin resistance (Shamsi-Goushki et al., 2020).

Fifty male Wistar rats were diagnosed with diabetes, and they were randomly assigned to receive either no supplements, 40 mg/kg curcumin, 80 mg/kg curcumin, or 40 mg/kg nanomicelle curcumin. Likewise, ten untreated mice served as healthy controls. Researchers checked levels of adiponectin, as well as AST, ALT, glucose, insulin, insulin resistance, triglycerides, cholesterol, HDL-C, LDL-C, and triglycerides. How much you weigh, how big your liver and heart are, and how much you think they weigh are all relevant factors. Blood insulin, adiponectin, HDL-C, body weight, and heart and pancreas function were all lowered, whereas serum AST, ALT, glucose, triglycerides, cholesterol, LDL-C, and insulin resistance were all raised, thanks to diabetes induction. Mouse glucose, cholesterol, and liver enzyme levels were all lowered by curcumin nanocells. Nano-sized curcumin improved the effectiveness in alleviating diabetes-related complications. The use of curcumin nanomicelles at therapeutic dosages shows promise in the treatment of diabetes (Dadgar, 2021).

Anti-cancer

Cancer is a broad word that encompasses a wide variety of illnesses that may begin in almost any part of the body. Cancer develops when aberrant cells divide uncontrollably, invade nearby tissues, and/or metastasize to other organs. Metastasizing is the second step, and it is a major contributor to cancer-related mortality. Among the various labels given to this disease, cancer is also known as neoplasm and malignant tumor (Zeliger, 2008).

The anti-cancer effects of nano-curcumin were investigated. After treating MCF7 cells with nano-curcumin and CAF, their vitality was determined using the MTT test. Effects of medications on cyclinD1 expression were evaluated using real-time polymerase chain reaction. A decrease in MCF7 viability was seen after treatment with nano-curcumin and CAF. Nano-curcumin was more effective than cyclophosphamide (63.31 percent), adriamycin (70.7 percent), and 5-fluorouracil (50.0 percent) in inhibiting cell growth (75.04 percent). When compared to CAF, curcumin was able to decrease cyclinD1 expression (Hosseini et al., 2019).

Lung (A549), liver (HepG2), and skin (SCC) cancer cell lines were used to examine the possible anticancer effects of curcumin nanodispersions (A431). Results showed that when tested against cancer cells, curcumin nanoparticles in water had an antiproliferative impact that was comparable to or even more potent than that of conventional curcumin in DMSO. Based on our results, nanoparticle-encapsulated curcumin has untapped therapeutic potential

as an additional therapy for clinical applications in the treatment of a wide range of cancers (Basniwal et al., 2014).

The hepatoprotective and anticancer properties of nanocurcumin were investigated. Acrylamide stimulates cell proliferation whereas curcumin and nanocurcumin decrease cell viability and enhance apoptosis in HepG2 and Huh-7 cancer cells. If you're looking for an even more potent anti-cancer agent, go no further than nanocurcumin. Acrylamide elevated blood alanine and aspartate aminotransferase activity and induced a rise in hepatic CYP2E1, P53, cleaved caspase-3, and COL1A1 expression in mice. Reversible curcumin, also known as nanocurcumin. Histopathology, fibrosis, and glycogen depletion brought on by Acrylamide are mitigated by nanocurcumin. Nanoparticle delivery of curcumin boosts the antioxidant and liver-protective properties of the compound (Atia et al., 2022).

Curcumin increases the sensitivity of cancer models to cisplatin. Cisplatin is used to treat cancers of the testicles, ovaries, and bladder. Ovarian tumor size and weight were both decreased by cisplatin and nanocurcumin treatment. There was a reduction in phosphorylation of Ki67, TGF-, PI3K, and Akt. JAK, STAT3, and IL-6 were all inhibited by cisplatin and nanocurcumin therapy. When nanocurcumin and cisplatin are used together to treat ovarian cancer models, proliferation is suppressed by downregulating the PI3K/Akt and JAK/STAT3 signaling pathways (Sandhiutami et al., 2021).

Curcumin-loaded polylactic acid-co-glycolic acid nanoparticles were tested against dimethyl hydrazine for its ability to induce colon cancer in male mice. In contrast to conventional curcumin, nanocurcumin has anticancer properties. There were six different kinds of mice: Disregarding Group I (Group-I was negative). Subfamily Curcumin. Curcumin that had been polylactate-co-glycolic acid-treated was given to Group III. Group IV was given dimethyl hydrazine. Hydrolyzed protein and curcumin were given to the Group V. Those in Group VI were given polylactate-co-glycolated curcumin and dimethyl hydrazine. When the experiment was over, the animals were killed (6 weeks). TNF exhibited percentage alterations compared to the dimethyl hydrazine group, and these changes were associated with substantial shifts in inflammatory markers and VEGF levels. V and VI regained 9.18 and 55.31 respectively. Between Groups V and VI, IL1 levels ranged from 7.45% to 50.37%. The IL6 yields in Group V were 4.86 and Group VI were 25.79 percent. There was a VEGF recovery of 16.98% in Group V and 45.12% in Group VI. Curcumin containing polylactate-co-glycolate was tested for its influence on colon histology after dimethyl hydrazine was used to alter the mucosal morphology of the colon. Polylactate-co-glycolate modified with

curcumin modulates cell cycle and PCNA (Elbassiouni et al., 2022).

Anti-hypertension

The prevalence of hypertension makes it a critical problem in public health. High blood pressure is responsible for around 12.8% of all fatalities each year, or the deaths of about 7.5 million individuals. According to the World Health Organization, by 2025, 1.56 billion persons will have hypertension. High blood pressure increases the risk for cardiovascular problems such chronic heart disease, stroke, and coronary artery disease. When blood pressure is elevated, the risk of stroke and coronary heart disease increases. Heart failure, peripheral vascular disease, renal and retinal bleeding, and blindness all exacerbate the problem (S. Singh et al., 2017).

Na+, K+-ATPase activity is elevated after taking nano-curcumin, proving its hypotensive action. Because this enzyme plays a key role in mediating vasorelaxation, a rise in its activity reveals the hypotensive impact of nano-curcumin supplementation. Nano-curcumin supplementation may also inhibit angiotensin-converting enzyme (ACE), which reduces oxidative stress induced by angiotensin-II and consequently increases NO generation. Reduced NO production causes oxidative stress, which in turn causes endothelial dysfunction and endothelial cell oxidative damage. Nano-curcumin supplementation decreased oxidative stress, increased endothelial-dependent vasodilation, and decreased DNA, lipid, and protein damage. As a result, NO synthesis and bioavailability went up (Talebi et al., 2021).

Curcumin's oral bioavailability was enhanced by the use of PLGA-curcumin nanoparticles, which resulted in higher plasma curcumin concentrations and significant improvements in cardiovascular responses and decreased liver fat deposition at doses 20-fold lower than those seen with curcumin alone (5 mg/kg/day compared to 100 mg/kg/day). These results suggest that nanoparticles may be preferable to capsules or aqueous suspensions for testing the effectiveness of curcumin for the treatment of metabolic disorders (du Preez et al., 2019).

Curcumin nanoparticle therapy decreased MCT-induced production of TNF-a, interleukin 1a (IL-1a), and nitrotyrosine in right ventricular tissue. The cardiovascular health of TGR(m-Ren2) hypertensive rats improved when curcumin was administered to the vessel walls in hyaluronic acid nanocapsules. Animals given a 4.5 mg/kg solution of curcumin showed no hypotensive effects, indicating that hyaluronic acid-based nanocapsules may be an efficient way to transfer the hydrophobic and bioavailable compound to the vessel wall (Li et al., 2022).

CONCLUSION

The utilization of nano curcumin as a therapeutic in the future offers a significant

amount of untapped potential. However, we believe that more study on the subject of the safety of curcumin in the form of nanoparticles is necessary. Our line of reasoning is that the medication in question should not only be effective in treating the ailment at hand, but it should also be risk-free and not be associated with any severe adverse effects. Due to the dearth of study in the area of nano curcumin safety, we are of the opinion that this should be carried out.

ACKNOWLEDGEMENT

Thank you to all those who have helped complete this article.

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