(International Print/Online Journal)

SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 5, Issue 4 , Page No: 531-537
July-August 2022

IJMSCR

Turmeric: A Boon for Oral Health

Dr. Swati Paraye[1]. Dr. Mangala R.[2] Dr. Shamli J. Sadawarte[3] Dr. Neha N. Kharwade[3] Dr. Sayojyata S. Bangar[3]

[1]Reader, [2]Head of the Department , [3]PG Student

Department of Oral Medicine Diagnosis And Radiology, Saraswati Dhanwantari Dental College, Parbhani

***Corresponding Author:**
Dr. Swati Paraye

Reader, Department of Oral Medicine Diagnosis And Radiology, Saraswati Dhanwantari Dental College, Parbhani

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract

Turmeric a spice that has long been recognized for its medicinal and anti-inflammatory property. It is main source of polyphenolcurcumin. It aids in the management of oralsubmucous fibrosis, metabolic syndrome, anxiety, arthritis and in it help in management of exercise induces inflammation. Turmeric also helpful in reduction of burning sensation in various oral lesions.

Keywords: Turmeric, curcumin, antioxidant

Introduction

Turmeric, *Curcuma longa* Linn., plant is a perennial herb belonging to the ginger family, *Zingiberaceae*, and is generally cultivated in south and southeast tropical Asia. The rhizome,which is also referred as the root of this plant and is used as a dietary spice for centuries.It has been used both orally and as a topical ointment to treat a variety of disorders..Ayurvedic medicine to treat hepatic disorders, anorexia, cough, diabetic wounds, rheumatoid arthritis, and sinusitis[(1).] Various preparations derived from turmeric display potential therapeutic effects against ulcer, dysentery,stomach upset, cancer, pains and wounds.

Taxonomy

Kingdom- Plantae ,Class- Liliospida,Sub class- Commelinids,Order-Zingiberales, Family- Zingiberaceae

Genus- Curcuma, Species- Curcuma longa

The wild turmeric is called C.aromatica and domestic species is called C.longa.

Active Constituents. The active constituents of turmeric are the flavonoid curcumin (diferuloylmethane) and various volatile oils, includingzingiberone,atlantone, and tumer one. Other constituents include sugars, proteins, and resins. The best-researched active constituent is curcumin, which comprises 0.3–5.4percent of raw turmeric.

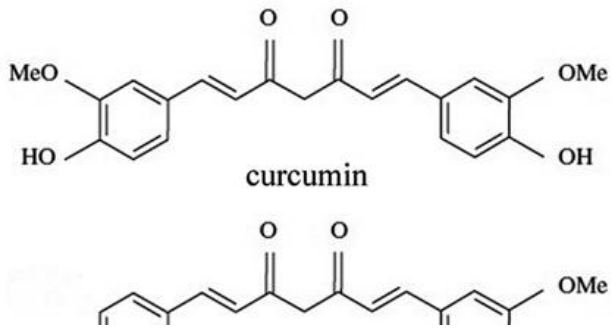
Commercial available form of curcumin is used as the main ingredient: capsules,turmeric oil,mouthwash,subgingival irrigant,pit and fissure irrigant.

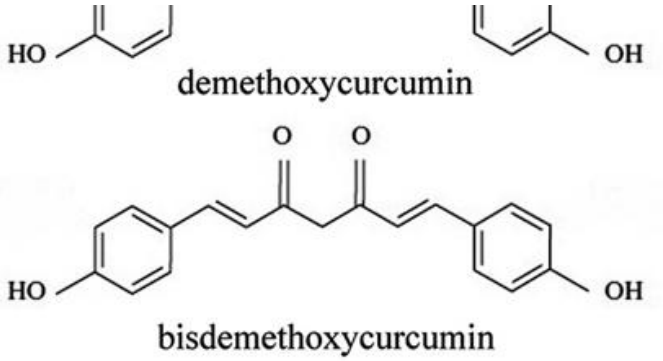
Chemical Properties

Curcumin, the most active component of turmeric, makes up 2–5% of this spice. The yellow color of the turmeric is due to the curcumin compound. Curcumin ($C_{21}H_{20}O_6$) was first described in 1910 by Lampe and Milobedeska and shown to be a diferuloylmethane, 1,7-bis (4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione [(2),] and is practically insoluble in water. Curcumin is a bis-*α*-*β*-unsaturated *β*-diketone; under acidic and neutral conditions, the bis-ketoformof the compound

predominates, and at pH above 8, the enolate form is generally found·Curcumin has a molecular weight of 368.7 and the commercial grade curcumin contains curcuminoids, 10–20% desmethoxycurcumin and less than 5% bisdesmethoxycurcumin[3]Curcumin is quite unstable at basic pH and degrades within 30 minutes. Human blood or antioxidants such as ascorbic acid, or the presence of 10% fetal bovine serum in the culture media prevents this degradation·[4] Turmeric is comprised of a group of three curcuminoids:

curcumin (diferuloylmethane), bisdemethoxycurcuminanddemethoxycurcumin (Fig.1), as well as volatile oils(atlantone, tumerone, and zingiberone), proteins, sugars and resins. The Curcumin is a lipophilic polyphenol that is nearly insoluble in water but is quite stable in the acidic pH of the stomach[4]





Bioavailability of curcumin

The reasons for reduced bioavailability of any agent within the body are poor absorption ,low intrinsic activity,high rate of metabolism, inactivity of metabolic products and/or rapid elimination and clearance fromthe body. Efficacy of curcumin as a therapeutic agent for various ailments have been suggested by studies andhave a predilection for strong intrinsic actyivity

However, studies over the past three to four decades related to the absorption, distribution, metabolism andexcretion of curcumin have revealed poor absorption and rapid metabolism of curcumin that severely curtails its bioavailability. However, the clinical application of curcumin in cancer treatment is considerably limited due toits serious poor delivery characteristics. In order to increase the hydrophilicity and drug delivery capability, it is encapsulated into copolymer. They were much more soluble in water than not only free curcumin but also other biodegradable polymer-encapsulated curcumin nanoparticles [5]

Pharmacological Properties Ofturmeric

1.Anti-Inflammatory Properties

Oral administration of curcumin in instances of acute inflammation was found to be as effective as cortisone or phenylbutazone. Oral administration of Curcuma longa significantly reduced inflammatory swelling [6]. C. longa's anti-inflammatory properties may be attributed to its ability to inhibit both biosynthesis of inflammatory prostaglandins from arachidonicacid, and neutrophil function during inflammatory states. Curcuminoids also inhibit COX, LOX,prostaglandins, thromboxane, nitric oxide elastase,phospholipases, leukotrienes, hyaluronidase,

collagenase, monocyte chemoattractant protein-1, interferon inducible protein,TNF and interleukin- 12. They also decrease prostaglandin formation and inhibit leukotriene biosynthesis via the lipoxygenase pathway [7]

Antioxidant properties

Water and fat-soluble extracts of turmeric and its curcumin component exhibit strong antioxidant activity,comparable to vitamins C and E. A study of ischemia demonstrated that curcumin pretreatment decreased ischemia-induced changes in the heart . An *in vitro* study measuring the effect of curcumin on endothelial hemeoxygenase-1, an inducible stress protein, was conducted utilizing bovine aortic

Volume 5, Issue 4; July-August 2022; Page No 531-537

endothelial cells. Incubation with curcumin resulted in enhanced cellular resistance to oxidative damage [8].Nagabhushan *et al.* 1987 tested curcumin against tobacco products and several environmental mutagens in a Salmonella/microsome test with or without Aroclor 1254- induced rat liver homogenate (S-9 mix), in order to determine the difference between mutagens. Curcumin inhibited the mutagenicity of adverse habit like bidi smoke condensate, cigarette smoke condensate and mishri (a tobacco product) and tobacco extracts in a dose-dependent and duration manner. Curcumin is only antimutagenic against mutagens which require metabolicactivation.[9]

Hepatoprotective properties

Studies have demonstrated turmeric's hepatoprotective properties from a variety of hepatotoxic injuries, including carbon tetrachloride (CCl4)[10]galactosamine and acetaminophen (paracetamol) [11]. Turmeric's hepatoprotective effect is mainly a result of its antioxidant properties [free radical scavenger] as well as its ability to decrease the formation of proinflammatory cytokines. Curcumin administration significantly decreased liver injury[12].Turmeric reduced infection with *Aspergillusparasiticus*and inhibited fungal aflatoxin production by 90%. Turmeric and curcumin also reversed biliary hyperplasia, fatty changes, and necrosis induced by aflatoxin production. Sodium curcuminate, a salt of curcumin, also exerts choleretic properties by increasing biliary excretion of bile salts, cholesterol, and bilirubin, as well as increasing bile solubility, therefore possibly preventing and treating cholelithiasis.

Anticarcinogenic Properties

Animal research demonstrates that inhibition at all three stages of carcinogenesis-initiation,

promotion, and progression. During initiation and promotion, curcumin modulates transcription factors controlling phase I and II detoxification of carcinogens;[12] down-regulates proinflammatory cytokines, free radical-activated transcription factors, and arachidonic acid metabolism vicyclooxygenase and lipoxygenase pathways; and scavenges free radicals[13]. Studies involving mice and rats, as well as in vitro studies utilizing human cell lines also, have demonstrated curcumin's hasability to inhibit carcinogenesis at three stages: tumor promotion, angiogenesis, and tumor growth[13]

Antimicrobial Properties

Turmeric extract inhibit the growth of a variety of bacteria, parasites, and pathogenic fungi. A study of chicks infected with the caecal parasite Eimera maxima demonstrated that diets supplemented with turmeric resulted in a reduction in small intestinal lesion scores and improved weight gain[14]. Another study shows that guinea pigs were infected with either dermatophytes, pathogenic molds, or yeast, found that topically applied turmeric oil inhibited dermatophytes and

pathogenic fungi. Improvements in lesions were observed in the dermatophyte- and fungi-infected guinea pigs, and at seven days post-turmeric application the lesions disappeared. Curcumin has also been found to have moderate activity against Plasmodium falciparum and Leishmania major organisms[15]

Disease Prevention & Treatment

Cancer:

The ability of curcumin to induce apoptosis in cultured cancer cells by several different mechanisms has generated scientific interest in the potential for curcumin to prevent some types of cancer. The inhibition of the development of chemically-induced cancer in animal models of oral, stomach, liver, and colon cancer has been done by the administration of curcumin orally. A supplementation up to 8 g/day for three months in patients with precancerous lesions of the mouth (oral leukoplakia), cervix (high grade cervical intraepithelial neoplasia), skin (squamous carcinoma in situ), or stomach (intestinal metaplasia) has been done by a Phase I study at Taiwan.

Histologic improvement on biopsy was intraepithelial neoplasia, two out of six patients with squamous carcinoma in situ, and one out of six patients with intestinal metaplasia. However, cancer developed in one out of seven patients with oral leukoplakia and one out of four patients with cervical intraepithelial neoplasia by the end of the treatment period.Curcumin was shown to "directly and irreversibly" affect the growth of new cancers in experiments on tumors The ability of curcumin to induce apoptosis in a variety of cancer cell lines and

Volume 5, Issue 4; July-August 2022; Page No 531-537

its low toxicity has led to scientific interest in its potential for cancer therapy. To date, most of the controlled clinical trials of curcumin supplementation in a cancer patients have been seen in Phase I trials. In patients with advanced colo-rectal cancer found that doses up to 3.6g/day for four months were well-tolerated, although the systemic bioavailability of oral curcumin was low in experiments on tumors.(16)

Inflammatory Diseases

Although the anti-inflammatory activity of curcumin has been demonstrated in cell culture and animal studies, few controlled clinical trials have examined the efficacy of curcumin in the treatment of inflammatory conditions. A preliminary intervention trial and study that compared curcumin with a nonsteroidal anti-inflammatory drug (NSAID) in a 18 rheumatoid arthritis patients found that improvements seen in morning stiffness, joint swelling and walking time after two weeks of curcumin supplementation (1,200mg/day) were comparable to those experienced after two weeks of phenylbutazone (NSAID) therapy (300mg/day).[16]

Dental Application Of Turmeric

Dental Pain And Periodontal Problems

Massaging the painful teeth with roasted, ground turmeric reduces and eliminates pain and swelling. A pastemade from 1 tsp of turmeric, ½ tsp of salt and ½ tsp of mustard oil can be used to treat gingival inflammation, gingivitis and periodontitis. It is recommended to rub the teeth and gums with this paste twice a day(17)

Pit And Fissure Sealant

It has been found that tinted pit and fissure sealant is used for application on tooth surfaces in order to prevent or reduce the incidence of dental caries. This sealant can be produced from a composition containing acrylic monomer and at least one colorant selected from the group consisting Annatto extract, turmeric extract, and -apo-8-carotenal [18].

Mouth Wash

Turmeric mouthwash prepared by dissolving 10mg of curcumin extract in 100 ml of distilled water and 0.005% of flavoring agent peppermint oil with pH adjusted to 4 was found to be as effective as most widely used chlorhexidine mouthwash. Though chlorhexidine gluconate is further more effective when anti plaque property was considered. The effect of turmeric may be due its anti-inflammatory action.

Reduction in total microbial count was observed in both the groups according to a study(19).

Subgingival Irrigation

In a study conducted by Suhag et al , periodontal sites were treated on day 0 (baseline) by a single episode of scaling and root planning. Subsequently, selected sites were irrigated (triple-irrigation regimen) with either saline (0.9%), chlorhexidine (0.2%), curcumin (1%), or served as non-irrigated control sites on day 0 (baseline) immediately following instrumentation. Triple-irrigation regimen was repeated for the next five consecutive days and on days 15 and 21 clinical parameters recorded while checking the probing pocket depth (PPD), bleeding on probing, and redness for 200 sites in 20 patients with chronic periodontitis. The results indicated that the irrigated sites had significant improvement in all parameters as compared with the non-irrigated sites on day 2-5. The curcumin group showed a significant reduction in benzoyl peroxide (100%) and redness (96%) when compared with the chlorhexidine group and the saline group on day 5. However, the difference between groups was not significant at next recall visits mean PPD reduction was significantly greater for the curcumin group than all other groups on all post-treatment days. Thus,1% curcumin solution can cause better resolution of inflammatory signs than chlorhexidine and saline irrigation as a subgingival irrigant.20

Influence Of Curcumin On Human Gingival Fibroblasts

Curcumin inhibits the expression of the CCL2 gene, which is also known as monocyte chemo attractant protein-1 (MCP-1). This inhibition was confirmed by Watanabe et al. who showed that (lipopolysaccharide)LPS-induced MCP-1 expression was blocked by curcumin in human gingival fibroblasts,resuting in itsapoptosis.(20) This property has been employed in the treatment of oral submucous fibrosis.The total daily dose of 2 g of Longvida lozenges has been used in the treatment of oral submucous fibrosis for a period of 3 months for resolution of fibrous bands. (22)

Curcumin induces cell cycle arrest in myofibroblasts Cell cycle analysis shows that curcumin treatment

Volume 5, Issue 4; July-August 2022; Page No 531-537

results in a dose-dependent increase in the proportion of myofibroblast cells in G0/G1 phase.

Recurrent Apthous Stomatitis (Ras)

RAS is an inflammatory condition of unknown etiology affecting the oral mucosa. Approximately 20% of the population suffers from RAS many time in their lives. The disease mainly involves non-keratinized mucosal surfaces and is characterized by single or multiple painful ulcers with periodic recurrence and healing. The appearance of ulcers is preceded by a prodrome of localized burning or pain which lasts for around 24-48 hr. The peak of onset is between 10 and 20 years and may continue for throughout the life. Reports have shown that in patients who used conventional antiseptic gel, the lesion healed only after the periods of time as in previous attacks. They experienced no early reduction in pain and frequency of recurrence also not reduced. The patients those using the curcumin oil reported that ulcers started healing earlier than in previous attacks; there was also early reduction in pain of ulcer. A follow-up for one-year has shown no recurrence in these patients.[23]

Curcumin And Precancerous Lesions

Oral lesions diagnosis is the most challenging in oral medicine practice. They are often chronic, intensely painful and can spontaneously remit, consequently hindering normal day life activities

The easy access of the treatmentthat allows the use of local delivery formulations directly to the lesion to treat the disease without causing adverse side effects. These lesions are currently managed by invasive surgery and approximately one-third of these lesions will reccur after surgery.

It is worth mentioning that Curcumin has a beneficial role in the treatment of various precancerous conditions like oral submucous fibrosis, leukoplakia and oral lichen planus. Turmeric extract and oil have demonstrated onco-preventive activity in *in vitro* and *in vivo* animal experiments [24, 25]. Most of the recent studies have showed its activity in systemic approaches [26, 27].Rai*et al* [28] previously reported curcumin efficacy when given orally for treatment of precancerous lesions at a dose as high as 8 g/day. The results showed that 25 patients with a diagnosed oral Leukoplakia, showed significant symptomatic relief and also reduction in clinical size of the lesion by treatment with curcumin. Curcumin increased the local level of vitamin C and E, while it decreased lipid peroxidation and DNA damage for patient suffered precancerous lesions, which suggested that the anti-precancerous effect is through the anti-oxidant and pro-oxidant pathways.

Chainani-Wu *et al* [29] reported that Curcuminoids at doses of 6000 mg/d in 3 divided doses were well tolerated and could prove efficacy in controlling signs and symptoms of oral Lichen planus.

Recently, it has been evidently reported that Curcumin treatment of co-culture between oral squamous cell carcinoma (SCC-25cells) and periodontal ligament fibroblasts (PDL) resulted in decrease of tumor cell migration and invasivity, reversal of epithelial-to-mesenchymal transition (EMT) in tumor cells and decrease of the EMT mediators gene expression and synthesis in fibroblasts which confirms the palliative potential of Curcumin in clinical application[30].

Safety Facets

Turmeric is known to offer many health benefits, cost-effective and has been considered to be pharmacologically safe. Although human consumption of curcumin as a dietary spice ranges up to 100 mg/day, it has been indicated that humans can tolerate a dose of curcumin up to 12 gm/day, without any toxic side effects.(31,32)Clinical studies in humans with high doses (2–12g) of curcumin have shown few side effects, with some subjects reporting mild nausea or diarrhea. More recently, curcumin was found to alter iron metabolism by chelating iron and suppressing the protein hepcidin, potentially causing iron and vitamin deficiency in susceptible patients. Further studies seem to be necessary to establish about benefit/risk profile of curcumin. (33)

Conclusion

Turmeric is one of the most precious and wonderful plant on earth and is being used as a natural wonder by the ancient people of India. As the number of research studies on the therapeutic effects of Curcumin keeps on increasing across the globe. It could be concluded that Curcumin holds a promising future in local and therapeutic applications specific for oral diseases such as aphthous ulcers and precancerous lesions . This review highlighted that curcumin is safe, non-toxic, effective and economical

Volume 5, Issue 4; July-August 2022; Page No 531-537

alternative with no side effects for many traditional drugs used in oral infection and periodontal diseases. Development of novel drug delivery systems such as nano-particles and solid lipid nano-particles loaded with curcumin seems to be very promising in enhancing its efficacy in addition to its stability and likely to be one of the thrust areas of research in future to optimize the use of this golden magical powder. Moreover, future research is required to determine the long-term effects of curcumin on a large number of subjects clinically.

References:

1. H. P. T. Ammon and M. A.Wahl, "Pharmacology of Curcuma longa," PlantaMedica, vol. 57, no. 1, pp. 1–7, 1991.
2. B. B. Aggarwal,A.Kumar, andA. C. Bharti, "Anticancer potential of curcumin: preclinical and clinical studies," Anticancer Research, vol. 23, no. 1 A, pp. 363–398, 2003.
3. R. A. Sharma, A. J. Gescher, and W. P. Steward, "Curcumin: the story so far," European Journal of Cancer, vol. 41, no. 13, pp. 1955–1968, 2005
4. Y.-J. Wang, M.-H.Pan, A.-L. Cheng, et al., "Stability of curcumin in buffer solutions and characterization of its degradation products," Journal of Pharmaceutical and Biomedical Analysis, vol. 15, no. 12, pp. 1867–1876, 1997
5. Kunnumakkara, Robert A. Newman, and Bharat B. Aggarwal .Mol. Pharmaceutics, 2007, 4 (6), 807-818.
6. Cronin, J.R, Curcumin: Old spice is a new medicine. Journal of Alternative & Complementary Therapies. 2003;9(1):34-8.
7. Bundy R, Walker AF, Middleton RW, Booth J, Turmeric extract may improve irritable bowel syndrome symptomology in otherwise healthy adults: a pilot study. J Altern Complement Med, 2004;10:1015-8.
8. Mortellini R, Foresti R, Bassi R, Green CJ. Curcumin, an antioxidant and anti-inflammatory agent, induces heme oxygenase-1 and protects endothelial cells against oxidative stress. Free RadicBiol Med. 2000;28:1303-12.
9. Nagabhushan M, Amonkar AJ, Bhide SV. In vitro antimutagenicity of curcumin against environmental mutagens.FoodChemToxicol. 1987;25(7):545-547.
10. Ruby J, Kuttan G, Babu KD, Rajashekharan KN, Kuttan R. Antitumor and oxidant activity of natural curcuminoids. Cancer Lett. 1995;94:79- 83.
11. Rao CV, Desai D, Rivenson A, Simi B, Amin S, Reddy BS. Chemoprevention of colon carcinogenesis by phenylethyl-3-methylcaffeate. Cancer Res. 1995;55(11):2310-5.
12. Park EJ, Jeon CH, Ko G, Kim J, Sohn DH. Protective effect of curcumin in rat liver injury induced by carbon tetrachloride.J Pharm Pharmacol. 2000;52:437-40.
13. Shao ZM, Shen ZZ, Liu CH, Sartippour MR, Go VL, Heber D, Nguyen M, Curcumin exerts multiple suppressive effects on human breast carcinoma cells. Int J Cancer, 2002;98(2):234-40.
14. Allen PC, Danforth HD, Augustine PC, Dietary modulation of aviancoccidiosis. Int J Parasitol, 1998;28:1131-40.
15. Rasmussen HB, Christensen SB, Kvist LP, Karazami A. A simple and efficient separation of the curcumins, the antiprotozoal constituents of Curcuma longa.Planta Med, 2000;66:396-8.
16. Joe B, Vijaykumar M, Lokesh BR. Biological properties of curcumin cellular and molecular mechanisms of action. Crit Rev Food SciNutr
17. Çıkrıkçı S, Mozioglu E, YılmazH,Biological activity of curcuminoids isolated from Curcuma longa.Rec Nat Prod. 2008;2:19–24.
18. Chaturvedi TP. Uses of turmeric in dentistry: An update. Indian J Dent Res 2009;20(1):107-9.
19. Waghmare PF, Chaudhary AU, Karhadkar VM, Jamkhande AS, Comparative evaluation of turmeric and chlorhexidinegluconate mouthwash in prevention of plaque formation and gingivitis: A clinical and microbiological study. J Contemp Dent Pract, 2011;12:221 2.
20. Suhag A, Dixit J, Dhan P. Role of curcumin as a subgingivalirrigant: A pilot study. PERIO: Periodontal Pract Today 2007; 2: 115-21.
21. Brouet I, Ohshima H. Curcumin, an anti-tumour promoter and antiinflammatory agent, inhibits induction of nitric oxide synthase in activated macrophages. BiochemBiophys Res Commun1995, 206(2),533-540.

Volume 5, Issue 4; July-August 2022; Page No 531-537

22. Hazarey VK, Sakrikar AR, Ganvir SM, Efficacy of curcumin in the treatment for oral submucous fibrosis - A randomized clinical trial. J Oral MaxillofacPathol. 2015 May-Aug;19(2):145-52.
23. Deepa DA, Anita B, Sreelatha KT. Comparative study of the efficacy of curcumin and turmeric oil aschemoprotective agents in oral submucous fibrosis: A clinical and histopathological evaluation. JIAOMR 2010; 22: 88-92.
24. Azuine, M.A. and Bhide, S.V., Chemopreventive effect of turmeric against stomach and skin tumors induced by chemical carcinogens in Swiss mice. Nutrition and Cancer, 17 (1), 1992, 77-83.
25. Azuine, M., Kayal, J., and Bhide, S., Protective role of aqueous turmeric extract against mutagenicity of direct-acting carcinogens as well as benzo [a] pyrene-induced genotoxicity and carcinogenicity. Journal of Cancer Research and Clinical Oncology, 118 (6), 1992, 447-452
26. Das, A., Balan, A., and Sreelatha, K., Comparative Study of the Efficacy of Curcumin and Turmeric Oil as Chemopreventive Agents in Oral Submucous Fibrosis: A Clinical and Histopathological Evaluation. Journal of Indian Academy of Oral Medicine & Radiology, 22 (2), 2010
27. Solanki, S., Prasad, S., Chinmaya, B., Tandon, S., and Ashwini, B., The Magic of Herbal Curcumin Therapy in Recurrent Oral Lichen Planus. American Journal of Ethnomedicine, 1 (1), 2014, 096-101.
28. Rai, B., Kaur, J., Jacobs, R., and Singh, J., Possible action mechanism for curcumin in pre-cancerous lesions based on serum and salivary markers of oxidative stress. Journal of Oral Science, 52 (2), 2010, 251-256.
29. Chainani-Wu, N., Madden, E., Lozada-Nur, F., and Silverman, S., High-dose curcuminoids are efficacious in the reduction in symptoms and signs of oral lichen planus. Journal of the American Academy of Dermatology, 66 (5), 2012, 752-760.
30. Dudás, J., Fullár, A., Romani, A., Pritz, C., Kovalszky, I., Schartinger, V.H., Sprinzl, G.M., and Riechelmann, H., Curcumin targets fibroblast–tumor cell interactions in oral squamous cell carcinoma. Experimental Cell Research, 319 (6), 2013, 800-809.
31. Ammon HP, Wahl MA. Pharmacology of curcuma longa.Planta Med 1991; 57(1): 1-7.
32. Lao CD, Ruffin MT, Normolle D et al. Dose escalation of a curcumanoid formulation. BMC Complement Altern Med 2006; 6: 10.
33. Sreejayan, Rao MN. Nitrous oxide scavenging by curcumoids. J Pharm 1997;49 (1); 105-107

Volume 5, Issue 4; July-August 2022; Page No 531-537