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BISACURONE

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ABSTRACT

Turmeric (Curcuma longa) contains various compounds that potentially improve health. Bisacurone is a turmeric-derived compound but has been less studied compared to other compounds, such as curcumin. In this study, we aimed to evaluate the anti-inflammatory and lipid-lowering effects of bisacurone in high-fat diet (HFD)-fed mice. Mice were fed HFD to induce lipidemia and orally administered bisacurone daily for two weeks. Bisacurone reduced liver weight, serum cholesterol and triglyceride levels, and blood viscosity in mice.

Turmeric and its components have various health beneficial functions. However, little is known about function of bisacurone, which is one of the sesquiterpenes in turmeric, at the compound level. In this study, we investigated the preventive effect of bisacurone on hepatic lipid accumulation and its mechanism in HepG2 cells and ICR mice.

Diabetes nephropathy (DN) is a serious diabetic problem that may progress to renal failure. The root of Curcuma longa L., often known as turmeric, provides various health benefits. Bisacurone is a bioactive terpenoid found in small amounts in turmeric that possesses anti-inflammatory and antioxidant properties. The present study focuses on the potential protective effects of bisacurone against DN via reducing renal inflammation, oxidative stress, and apoptosis.

Keywords: Bisacurone; High-Fat Diet; Cholesterol; Blood Viscosity; Pro-Inflammatory Cytokines; NF-Kb Pathway, Diabetes Nephropathy, Hepatic Lipid Accumulation, Oxidative Stress, Apoptosis.

I. INTRODUCTION

Turmeric

Turmeric (Curcuma longa) contains various compounds that potentially improve health. Bisacurone is a turmeric-derived compound but has been less studied compared to other compounds, such as curcumin.

Fig.1 [https://images.app.goo.gl/8fw1RpKbFEYsHfNE9

Taxonomic Details:

Botanical Name - Curcuma Longa
Family - Zingiberaceae
Common Name - Turmeric
Part used - Dried rhizomes
Urdu Name - Haldi
Kingdom - Plantae

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Subkingdom - Tracheobionts
Super division - Spermatophyta
Division - Mangoliophyta
Order - Zingiberales

Structure of Bisacurone

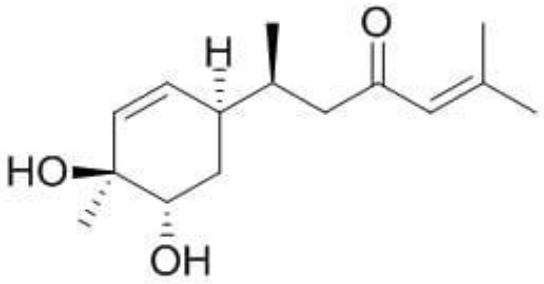

Fig 2. Structure of bisacurone

IUPAC Name: (6S)-6-[(1R,4S,5S)-4,5-Dihydroxy-4-methylcyclohex-2-en-1-yl]-2-methylhept-2-en-4-one

Molecular formula : $C_{15}H_2$

MolecularWeight:252.354 g·mol −1

Activity:

1) Antidiabetic:

Diabetes mellitus (DM) is a metabolic condition characterized by chronic hyperglycemia caused by inadequate insulin production from pancreatic ββ -cells and/or insulin resistance on target cells. Diabetes cases are expected to increase from 171 million in 2000 to 366 million by 2030. Diabetic kidney disease (DKD) is a severe diabetes complication that may lead to chronic kidney disease (CKD). 40–50% of newly diagnosed kidney transplant patients have diabetic nephropathy (DN). The typical microvascular effects of DN include mesangial enlargement, glomerular hypertrophy, interstitial fibrosis, and perhaps arteriolar dilation.[4] In addition to these glomerular filtration rates (GFR) abnormalities, DN may induce hyperfiltration, microalbuminuria, proteinuria, and scattered glomerulosclerosis, which often results in severe renal failure. Besides, DN has been associated with diabetes-related oxidative stress, lipid abnormalities, inflammatory pathways, renal hemodynamic changes, and insulin resistance.

An excess of reactive oxygen species (ROS) causes the development of DN, which is induced by hyperglycemia and oxidative stress. Excess ROS causes podocyte degeneration and death in the diabetic kidney. Besides, NADPH oxidase (NOX), specifically the widely spread NOX4, is the primary source of ROS at DN NOX4-produced ROS is mainly responsible for fibrosis and podocyte death in diabetic kidneys. Oxidative stress has a role in the molecular mechanism causing fibrosis in various organs, including DN. Nrf2 is a transcription factor involved in antioxidant and anti-inflammatory responses, making it an important cellular defense mechanism. Excess ROS may damage cellular macromolecules and activate redox-sensitive molecules like nuclear factor-kappa B (NF-kappa B), resulting in pro-inflammatory mediators and other cellular degradation. Diabetes problems and DN have been linked to oxidative damage, NF-kB activation, and increased pro-inflammatory conciliators. In addition, TLR4/MyD88/NF-kB signaling augments the inflammatory cascade in diabetic kidneys by regulating the production of pro-inflammatory mediators. Furthermore, DN induces oxidative stress and inflammation, which leads to a series of events that results in apoptosis and cell death.

Herbal medicine has a long history of usage in the treatment of diabetes. Several studies indicate that these herbs may benefit humans and animals with DM. Because oxidative stress, inflammation, and apoptosis contribute to diabetes and its complications, medicinal herbs with antioxidant properties are utilized to alleviate these side effects, including DN. Curcuma longa liter. (Zingiberaceae) is a plant that grows in both tropical and subtropical areas. Turmeric powder is widely used as a spice and medicinal throughout Asia. Turmeric extract has around 200 components, including phenolic chemicals and terpenoids. Several studies have shown that curcumin, turmeric's major bioactive component has medicinal properties. Curcumin is

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responsible for anti-inflammatory, antioxidant, neuroprotective, and anticancer activities.[16] Furthermore, bisacurone is a bioactive terpenoid found in low concentrations of turmeric. Previous research has demonstrated that bisacurone can fight with free radicals, alter Nrf2/HO-1 signaling in the kidneys of diabetic rats, and lower oxidative stress, inflammation and cell death. In this study, the authors looked at the protective effects of bisacurone on diabetic kidneys in Sprague Dawley rats. The authors mainly investigated the underlying molecular mechanisms via the Nrf2/NF-kB/caspase-3 pathways in diabetic rat kidneys.

2) Hypolipidemic and Anti-Inflammatory:

Turmeric (Curcuma longa) has been widely used as a food spice and attracted interest as a source of compounds with antitumor, anti-inflammatory, and lipid-lowering effects. To date, approximately 235 compounds have been isolated from C. longa, most of which are phenolic compounds and terpenoids . Among them, curcumin is considered the most active constituent of C. longa. The health benefits of curcumin have been extensively assessed for the prevention and treatment of inflammatory diseases , whereas those of other compounds in C. longa have not been extensively investigated.

Bisacurone, a phytochemical present in C. longa, is a bisabolane-type sesquiterpenoid consisting of three isoprene-derived units . Bisacurone inhibits TNF-α-mediated soluble vascular cell adhesion molecule-1 (VCAM-1) expression in inflammatory monocytes and cancer cells . Feeding mice with bisacurone reduced total lipid, triglyceride, and cholesterol levels in the liver. C. longa extracts containing bisacurone suppress the development of ethanol-induced liver injury and non-alcoholic fatty liver disease (NAFLD) in murine models by reducing serum levels of pro-inflammatory cytokines, such as IL-6 and TNF-α, and improving liver weight, fat accumulation, and levels of biochemical markers, such as serum cholesterol and aspartate aminotransferase (AST)/alanine aminotransferase (ALT). A randomized, double-blind intervention trial involving middle-aged and elderly subjects with overweight or mild hypertension showed that a hot water extract of C. longa containing bisacurone decreased the serum levels of C-reactive protein, IL-6, TNF-α, and VCAM-1.

The expression of inflammatory markers is increased in secondary lymphoid organs, in addition to liver and adipose tissues, in diet-induced obese mice . However, the effects of bisacurone on the pro-inflammatory responses of immune cells in the lymphoid tissues remain unclear. In the present study, we aimed to assess the hypolipidemic and anti-inflammatory effects of bisacurone in high-fat diet (HFD)-fed mice. In addition, we attempted to elucidate the mechanism responsible for the anti-inflammatory effect of bisacurone using a murine macrophage cell line RAW264.7. This study provides insights into the use of bisacurone as a hypolipidemic and anti-inflammatory molecule for the development of functional foods.

3) Suppresses hepatic lipid accumulation:

Studied on bisacurone suppresses hepatic lipid accumulation through inhibiting lipogenesis and promoting lipolysis.

Turmeric and its components have various health beneficial functions. However, little is known about function of bisacurone, which is one of the sesquiterpenes in turmeric, at the Type 2 diabetes was developed in rats by consuming a high-fat/high-sugar diet for 8 weeks, followed by a low dose of streptozotocin and bisacurone for 4 weeks.

hepatic lipid accumulation and its mechanism in HepG2 cells and ICR mice. In HepG2 cells, bisacurone significantly inhibited fatty acid-induced intracellular lipid accumulation in /a dose-dependent manner. Bisacurone at 10 μM increased protein expression of peroxisome proliferator-activated receptor α and carnitine palmitoyltransferase-1A accompanied by phosphorylation of AMP-activated protein kinase. In the liver of ICR mice, bisacurone decreased total lipids, triglyceride, and cholesterol contents. Bisacurone at 10 mg/kg body weight increased phosphorylation of AMP-activated protein kinase, and its downstream acetyl-CoA carboxylase as a rate-limiting enzyme for lipogenesis, while it decreased the nuclear translocation level of sterol regulatory element-binding protein 1 and carbohydrate-responsive element-binding protein as the major transcription factors for lipogenesis. On the other hand, bisacurone promoted lipolysis by up-expression of peroxisome proliferator-activated receptor α and carnitine palmitoyltransferase-1A. Thus, bisacurone might be a va luable food factor for preventing hepatic lipid accumulation by inhibiting lipogenesis and promoting lipolysis through phosphorylation of AMP-activated protein kinase.

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4) Antioxidant and Angiogenic activity:

Studied on Bisacurone gel ameliorated burn wounds in experimental rats via its anti-inflammatory, antioxidant, and angiogenic properties. Purpose of this study to investigate putative mechanism of wound healing for chitosan-based bisacurone gel against secondary burn wounds in rats. The study done by using this method, a second-degree burn wound with an open flame using mixed fuel (2 mL, 20 seconds) was induced in Sprague Dawley rats (male, 180-220 g, n = 15, each) followed by topical treatments with either vehicle control (white petroleum gel, 1%), silver sulfadiazine (1%) or bisacurone gel (2.5, 5, or 10%) for 20 days. Wound contraction rate and paw withdrawal threshold were monitored on various days. Oxidative stress (superoxide dismutase, glutathione, malondialdehyde, and nitric oxide), pro-inflammatory cytokines (tumour necrosis factor-alpha, interleukins by enzyme-linked immunosorbent assay), growth factors (transforming growth factor-β, vascular endothelial growth factor C using real time polymerase chain reaction and Western blot assay) levels, and histology of wound skin were assessed at the end.

Side Effects:

- Dizziness
- Nausea
- Headache
- Drowsiness
- Abnormal dreams
- Chest pain.
- Numbness of the hands and feet and muscle tremors or restlessness can also happen.

II. CONCLUSION

For the first time, our findings show that bisacurone reduces blood glucose levels significantly and improves DN-induced kidney damage. The bisacurone reduces changes in renal biochemical markers, lipid profile, oxidative stress and inflammation, fibrosis and apoptosis. Our study believes bisacurone might be applicable in treating DN. Furthermore, the current work adds to the experimental evidence o curcumin's therapeutic potential and novel medication development.

These findings suggested that bisacurone gel can be a potential candidate to treat burn wounds via its anti-inflammatory, antioxidant, and angiogenic properties.

III. REFERENCES

[1] Eizirik DL, Pasquali L, Cnop M. Pancreatic β-cells in type 1 and type 2 diabetes mellitus: different pathways to failure. Nat Rev Endocrinol 2020; 16: 349–362.

[2] Lovic D, Piperidou A, Zografou I, et al. The growing epidemic of diabetes mellitus. Curr Vasc Pharmacol 2020; 18: 104–109.3. Garla V, Kanduri S, Yanes-Cardozo L, et al. Management of diabetes mellitus in chronic kidney disease. Minerva Endocrinol 2019; 44: 273–287.

[3] Tuttle KR, Agarwal R, Alpers CE, et al. Molecular mechanisms and therapeutic targets for diabetic kidney disease. Kidney Int 2022; 102: 248–260.

[4] Rico-Fontalvo J, Aroca G, Cabrales J, et al. Molecular mechanisms of diabetic kidney disease. Int J Mol Sci 2022; 23: 8668.

[5] Sagoo MK, Gnudi L. Diabetic nephropathy: an overview. Methods Mol Biol 2020; 2067: 3–7.

[6] Al-Rasheed NM, Al-Rasheed NM, Bassiouni YA, et al. Simvastatin ameliorates diabetic nephropathy by attenuating oxidative stress and apoptosis in a rat model of streptozotocin-induced type 1 diabetes. Biomed Pharmacother 2018; 105: 290–298.

[7] Lee SR, An EJ, Kim J, et al. Function of NADPH oxidases in diabetic nephropathy and development of nox inhibitors. Biomol Ther (Seoul) 2020; 28: 25–33.

[8] Yang Q, Wu FR, Wang JN, et al. Nox4 in renal diseases: an update. Free Radic Biol Med 2018; 124: 466–472.

[9] Su H, Wan C, Song A, et al. Oxidative stress and renal fibrosis: mechanisms and therapies. Adv Exp Med Biol 2019; 1165: 585–604.

[10] Arellano-Buendía AS, Tostado-González M, García-Arroyo FE, et al. Anti-inflammatory therapy modulates Nrf2-Keap1 in kidney from rats with diabetes. Oxid Med Cell Longev 2016; 2016: 4693801.
[11] Aghadavod E, Khodadadi S, Baradaran A, et al. Role of oxidative stress and inflammatory factors in diabetic kidney disease. Iran J Kidney Dis 2016; 10: 337–343.
[12] Ahmed S, Mundhe N, Borgohain M, et al. Diosmin modulates the NF-kB signal transduction pathways and downregulation of various oxidative stress markers in alloxan-induced diabetic nephropathy. Inflammation 2016; 39: 1783–1797.
[13] Liu P, Li F, Xu X, et al. 1,25(OH)(2)D(3) provides protection against diabetic kidney disease by downregulating the TLR4-MyD88-NF-κB pathway. Exp Mol Pathol 2020; 114: 104434.
[14] Giribabu N, Karim K, Kilari EK, et al. Phyllanthus niruri leaves aqueous extract improves kidney functions, ameliorates kidney oxidative stress, inflammation, fibrosis and apoptosis and enhances kidney cell proliferation in adult male rats with diabetes mellitus. J Ethnopharmacol 2017; 205: 123–137.
[15] Menon VP, Sudheer AR. Antioxidant and anti-inflammatory properties of curcumin. Adv Exp Med Biol 2007; 595: 105–125.
[16] Ak T, Gülçin I. Antioxidant and radical scavenging properties of curcumin. Chem Biol Interact 2008; 174: 27–37.
[17] Cole GM, Teter B, Frautschy SA. Neuroprotective effects of curcumin. Adv Exp Med Biol 2007; 595: 197–212.
[18] Nair A, Amalraj A, Jacob J, et al. Non-curcuminoids from turmeric and their potential in cancer therapy and anticancer drug delivery formulations. Biomolecules 2019; 9: 13.
[19] Cui Y, Chi J, Wang L. Protective efficacy of bisacurone in diabetic cardiotoxicity in experimental animals via downregulation of inflammatory and apoptotic pathways. Lat Am J Pharm 2020; 39: 2507–2519.
[20] Wang L, Wang P, Li X, et al. Combination CTLA-4 immunoglobulin treatment and ultrasound microbubble-mediated exposure improve renal function in a rat model of diabetic nephropathy. Aging (Albany NY) 2021; 13: 8524–8540.
[21] Giribabu N, Eswar Kumar K, Swapna Rekha S, et al. Vitis vinifera (muscat variety) seed ethanolic extract preserves activity levels of enzymes and histology of the liver in adult male rats with diabetes. Evid Based Complement Alternat Med eCAM 2015; 2015: 542026.
[22] Wahab NAA, Giribabu N, Kilari EK, et al. Abietic acid ameliorates nephropathy progression via mitigating renal oxidative stress, inflammation, fibrosis and apoptosis in high fat diet and low dose streptozotocin-induced diabetic rats. Phytomedicine 2022; 107: 154464.
[23] Zhang Y, Luo L, Li Z, et al. Anti-lipid peroxidation, α-glucosidase and α-amylase inhibitory effects of the extract of capitula of coreopsis tinctoria nutt. and protection effects on high-fat/high-sugar and streptozotocin-induced type 2 diabetes in mice. Chem Biodivers 2019; 16: e1900514.
[24] Mohiti-Ardekani J, Asadi S, Ardakani AM, et al. Curcumin increases insulin sensitivity in C2C12 muscle cells via AKT and AMPK signaling pathways. Cogent Food Agric 2019; 5: 1577532
[25] Ghorbani Z, Hekmatdoost A, Mirmiran P. Anti-hyperglycemic and insulin sensitizer effects of turmeric and its principle constituent curcumin. Int J Endocrinol Metab 2014; 12: e18081.
[26] Pourfarjam Y, Rezagholizadeh L, Nowrouzi A, et al. Effect of Cichorium intybus L. seed extract on renal parameters in experimentally induced early and late diabetes type 2 in rats. Ren Fail 2017; 39: 211–221.
[27] Hidayat R, Wulandari P. Effects of Andrographis paniculata (Burm. F.) extract on diabetic nephropathy in rats. Rep Biochem Mol Biol 2021; 10: 445–454.
[28] Navarro-González JF, Mora-Fernández C, Muros de Fuentes M, et al. Effect of pentoxifylline on renal function and urinary albumin excretion in patients with diabetic kidney disease: the PREDIAN trial. J Am Soc Nephrol 2015; 26: 220–229.
[29] Bagherniya M, Soleimani D, Rouhani MH, et al. The use of curcumin for the treatment of renal disorders: a systematic review of randomized controlled trials. Adv Exp Med Biol 2021; 1291: 327–343.
[30] Parsamanesh N, Moossavi M, Bahrami A, et al. Therapeutic potential of curcumin in diabetic complications. Pharmacol Res 2018; 136: 181–193.

[31] Liamis G, Liberopoulos E, Barkas F, et al. Diabetes mellitus and electrolyte disorders. World J Clin Cases 2014; 2: 488–496.
[32] Zhang Y, Ma KL, Liu J, et al. Inflammatory stress exacerbates lipid accumulation and podocyte injuries in diabetic nephropathy. Acta Diabetol 2015; 52: 1045–1056.
[33] Futuhi F, Naghibzadeh Tahami A, Azmandian J, et al. The effects of curcumin-containing supplementations on inflammatory markers and lipid profiles in patients with chronic kidney diseases: a systematic review and meta-analysis of randomized controlled trials. J Complement Integr Med 2022; 19: 531–541.
[34] Ashida H, Tian X, Kitakaze T, et al. Bisacurone suppresses hepatic lipid accumulation through inhibiting lipogenesis and promoting lipolysis. J Clin Biochem Nutr 2020; 67: 43–52.
[35] Pourghasem M, Shafi H, Babazadeh Z. Histological changes of kidney in diabetic nephropathy. Caspian J Intern Med 2015; 6: 120–127.
[36] Huang J, Huang K, Lan T, et al. Curcumin ameliorates diabetic nephropathy by inhibiting the activation of the SphK1-S1P signaling pathway. Mol Cell Endocrinol 2013; 365: 231–240.
[37] Kurutas EB. The importance of antioxidants which play the role in cellular response against oxidative/nitrosative stress: current state. Nutr J 2016; 15: 71.
[38] Ma Q. Role of nrf2 in oxidative stress and toxicity. Annu Rev Pharmacol Toxicol 2013; 53: 401–426.
[39] Kashihara N, Haruna Y, Kondeti VK, et al. Oxidative stress in diabetic nephropathy. Curr Med Chem 2010; 17: 4256–4269.
[40] Xie YL, Chu JG, Jian XM, et al. Curcumin attenuates lipopolysaccharide/d-galactosamine-induced acute liver injury by activating Nrf2 nuclear translocation and inhibiting NF-kB activation. Biomed Pharmacother 2017; 91: 70–77.
[41] Ibrahim SG, El-Emam SZ, Mohamed EA, et al. Dimethyl fumarate and curcumin attenuate hepatic ischemia/reperfusion injury via Nrf2/HO-1 activation and anti-inflammatory properties. Int Immunopharmacol 2020; 80: 106131.
[42] Gonzalez Y, Herrera MT, Soldevila G, et al. High glucose concentrations induce TNF-α production through the down-regulation of CD33 in primary human monocytes. BMC Immunol 2012; 13: 19.
[43] Sun DI, Nizamutdinova IT, Kim YM, et al. Bisacurone inhibits adhesion of inflammatory monocytes or cancer cells to endothelial cells through down-regulation of VCAM-1 expression. Int Immunopharmacol 2008; 8: 1272–1281.
[44] Djudjaj S, Boor P. Cellular and molecular mechanisms of kidney fibrosis. Mol Aspects Med 2019; 65: 16–36.
[45] Isaka Y. Targeting TGF-β signaling in kidney fibrosis. Int J Mol Sci 2018; 19: 2532.
[46] Herder C, Carstensen M, Ouwens DM. Anti-inflammatory cytokines and risk of type 2 diabetes. Diabetes Obes Metab 2013; 15: 39–50.
[47] loria S., Mehta J., Chandel A., Sekar M., Rani N.N.I.M., Begum M.Y., Subramaniyan V., Chidambaram K., Thangavelu L., Nordin R., et al. A Comprehensive Review on the Therapeutic Potential of Curcuma Longa Linn. in Relation to Its Major Active Constituent Curcumin. Front. Pharmacol. 2022;13:820806. doi: 10.3389/fphar.2022.820806. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
[48] Sharifi-Rad J., Rayess Y.E., Rizk A.A., Sadaka C., Zgheib R., Zam W., Sestito S., Rapposelli S., Neffe-Skocińska K., Zielińska D., et al. Turmeric and Its Major Compound Curcumin on Health: Bioactive Effects and Safety Profiles for Food, Pharmaceutical, Biotechnological and Medicinal Applications. Front. Pharmacol. 2020;11:01021.
doi: 10.3389/fphar.2020.01021. [PMC free article] [PubMed] [CrossRef] [Google Scholar]
[49] Hosseini A., Hosseinzadeh H. Antidotal or Protective Effects of Curcuma Longa (Turmeric) and Its Active Ingredient, Curcumin, against Natural and Chemical Toxicities: A Review. Biomed. Pharmacother. 2018;99:411–421. doi: 10.1016/j.biopha.2018.01.072. [PubMed] [CrossRef] [Google Scholar]
[50] Srivastava B.B.L., Ripanda A.S., Mwanga H.M. Ethnomedicinal, Phytochemistry and Antiviral Potential of Turmeric (Curcuma longa) Compounds. 2022;2:17.
doi: 10.3390/compounds2030017. [CrossRef] [Google Scholar]

[51] Li S., Yuan W., Deng G., Wang P., Yang P., Aggarwal B.B. Chemical Composition and Product Quality Control of Turmeric (Curcuma longa L.) Pharm. Crop. 2011;2:28–54. doi: 10.2174/2210290601102010028. [CrossRef] [Google Scholar]

[52] Farhood B., Mortezaee K., Goradel N.H., Khanlarkhani N., Salehi E., Nashtaei M.S., Najafi M., Sahebkar A. Curcumin as an Anti-Inflammatory Agent: Implications to Radiotherapy and Chemotherapy. J. Cell. Physiol. 2019;234:5728–5740. doi: 10.1002/jcp.27442. [PubMed] [CrossRef] [Google Scholar]

[53] Wang Q., Ye C., Sun S., Li R., Shi X., Wang S., Zeng X., Kuang N., Liu Y., Shi Q., et al. Curcumin Attenuates Collagen-Induced Rat Arthritis via Anti-Inflammatory and Apoptotic Effects. Int. Immunopharmacol. 2019;72:292–300. doi: 10.1016/j.intimp.2019.04.027. [PubMed] [CrossRef] [Google Scholar]

[54] Shu H.-Z., Peng C., Bu L., Guo L., Liu F., Xiong L. Bisabolane-Type Sesquiterpenoids: Structural Diversity and Biological Activity. Phytochemistry. 2021;192:112927. doi: 10.1016/j.phytochem.2021.112927. [PubMed] [CrossRef] [Google Scholar]

[55] Sun D.-I., Nizamutdinova I.T., Kim Y.M., Cai X.F., Lee J.J., Kang S.S., Kim Y.S., Kang K.M., Chai G.Y., Chang K.C., et al. Bisacurone Inhibits Adhesion of Inflammatory Monocytes or Cancer Cells to Endothelial Cells through Down-Regulation of VCAM-1 Expression. Int. Immunopharmacol. 2008;8:1272–1281. doi: 10.1016/j.intimp.2008.05.006. [PubMed] [CrossRef] [Google Scholar]

[56] Ashida H., Tian X., Kitakaze T., Yamashita Y. Bisacurone Suppresses Hepatic Lipid Accumulation through Inhibiting Lipogenesis and Promoting Lipolysis. J. Clin. Biochem. Nutr. 2020;67:43–52. doi: 10.3164/jcbn.20-16. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

[57] Uchio R., Higashi Y., Kohama Y., Kawasaki K., Hirao T., Muroyama K., Murosaki S. A Hot Water Extract of Turmeric (Curcuma longa) Suppresses Acute Ethanol-Induced Liver Injury in Mice by Inhibiting Hepatic Oxidative Stress and Inflammatory Cytokine Production. J. Nutr. Sci. 2017;6:e3. doi: 10.1017/jns.2016.43. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

[58] Sudeep H., Venkatakrishna K., Sundeep K., Vasavi H.S., Raj A., Chandrappa S., Shyamprasad K. Turcuron: A Standardized Bisacurone-Rich Turmeric Rhizome Extract for the Prevention and Treatment of Hangover and Alcohol-Induced Liver Injury in Rats. Pharmacogn. Mag. 2020;16:263–271. doi: 10.4103/pm.pm_32_20. [CrossRef] [Google Scholar]

[59] Gouthamchandra K. Bioactive Compound Bisacurone in the Turmeric Extract (Turcuron) Prevents Non-Alcoholic Fatty Liver Disease by Reduction of Lipogenesis. Indian J. Pharm. Educ. Res. 2021;55:s48–s55. doi: 10.5530/ijper.55.1s.36. [CrossRef] [Google Scholar]

[60] Uchio R., Muroyama K., Okuda-Hanafusa C., Kawasaki K., Yamamoto Y., Murosaki S. Hot Water Extract of Curcuma longa L. Improves Serum Inflammatory Markers and General Health in Subjects with Overweight or Prehypertension/Mild Hypertension: A Randomized, Double-Blind, Placebo-Controlled Trial. Nutrients. 2019;11:1822. doi: 10.3390/nu11081822. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

[61] Feng L., Huang F., Ma Y., Tang J. The Effect of High-Fat Diet and Exercise Intervention on the TNF-α Level in Rat Spleen. Front. Immunol. 2021;12:671167. doi: 10.3389/fimmu.2021.671167. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

[62] da Silva R.N.O., Santos-Eichler R.A., Dias C., Rodrigues S.F., Skiba D.S., Landgraf R.G., de Carvalho M.H.C., Guzik T., Fock R.A., Akamine E.H. Immune Spleen Cells Attenuate the Inflammatory Profile of the Mesenteric Perivascular Adipose Tissue in Obese Mice. Sci. Rep. 2021;11:11153. [PMC free articlePubMedGoogle Scholar