



## A comprehensive review on antidiabetic properties of turmeric

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**Abstract:** Diabetes is a major risk factor for coronary artery diseases, nephropathy, neuropathy, retinopathy and many other complications. Turmeric and its bioactive compounds like curcumin had great therapeutic abilities against diabetes. In this review, we summarized the current basic and clinical evidence about the potential of curcumin/curcuminoids for the treatment of diabetes mellitus, mainly by its hypoglycemic, antioxidant, and anti-inflammatory properties. Curcumin, a natural compound found in the rhizome of *Curcuma longa*, is well known for its numerous biological activities, as demonstrated by several studies supporting that curcumin possesses hypoglycaemic, hypolipidemic, anti-inflammatory and antioxidant properties, among others. These effects have been explored to the attenuation of hyperglycaemia and progression of DM complications, being appointed as a potential therapeutic approach. The interactions between curcumin and conventional antidiabetic drugs might be explored for the therapeutic management of diabetes mellitus.

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### Introduction

Vegetables and fruits have gained much importance in diet because they are rich in vitamins, especially vitamin C, vitamin A, phytochemicals including antioxidants, fibers and minerals. Fruits and vegetables have higher amount of nutrients and also provide potassium etc. Higher fruit and vegetables intake protective against several degenerative diseases like cancer, atherosclerosis (Hornick *et al.*, 2011; Razzaq *et al.*, 2020). Phyto-derivatives with anti-hyperglycemic properties have been used in conventional medicine, traditional cure systems, and as CAM therapy. A lot of herbal, biological and botanical products declare to lower blood glucose or reduce the chronic symptoms of hyperglycemia (Kim *et al.*, 2009). Phytochemicals coupled with dietary modifications gained a lot of importance because of their effect on the health of humans and in result it reduces the risk of life threatening disorders. The active ingredient present in the food is responsible for its disease preventive ability. This thing encouraged the community health practitioners to increase the therapeutic capacity of commercially prepared food (Bech-Larsen & Scholderer, 2007; Kim *et al.*, 2011). Phytochemicals are covering more than 8000 different varieties according to structure; these are basically not the nutritive parts of plants. The daily base

consumption of these bioactive ingredients decreases the incidence of many diseases because of its high oxygen scavenging ability (Manach *et al.*, 2004). Dietary pattern based on these phytonutrients decreased the medical expenses by promoting health in this way it has an financial benefit for the state (Epstein *et al.*, 2010). Due to various side effects of conventional medicines people are moving towards natural methods of treatment. That is why nutraceuticals have gained so much fame around the world due to their health promoting potential. (EL-Sohaimy, 2012; Epsin *et al.*, 2007). Such type of addition in diet has the ability to minimize the harmful effects of free radicles and boost the immune system ). Bioactive compounds presence in spices has been proved and their presence in food work as natural protective compounds (Srinivasan, 2005). According to FAO (2005), spices are a substance which gives aroma and used to flavor food. One of the most importantly used spices is turmeric, used as additional culinary product, as a drug, dye and in beauty products (Lal, 2012). Turmeric is one of the most commonly used plants in many countries especially in Asia.

Its rhizome used as spice for flavoring and coloring of the foods. It is basically an evergreen tree

having leaves which are very large, a stem which is very small and its rhizomes are yellowish in color. any type of harm that is caused by inflammation turmeric is used to cure that ailment. It is used for the treatment of swelling caused due to injury (Ishita *et al.*, 2004). Turmeric belongs to class Liliopsdia, family Zingiberaceae, Genus *Curcuma* while species *curcuma longa*. Its powder is used for the cure of cough, anorexia, liver disorders, abdominal disorders and diabetic wounds. Pakistan is second biggest grower of turmeric, although production quantity per acre is very low. Turmeric composed of 5.1% fat, 13.1% moisture, 3.5 % minerals, 69.4% carbohydrates and 6.3% protein. Potassium, Phosphorus iron and sodium quantity in turmeric is about 0.031, 71.035 & 0.009 mg respectively. The amount of copper in 100g of turmeric is about in a range of 0.001 to 0.003 mg/100kg. It contains a filthy amount about 91 mg of fat soluble vitamin named as vitamin A.

Turmeric was named in India as golden spice. In 3000 BC Harappan civilization cultivated the turmeric plant. it is used as home medicines for illness and used for different treatment systems including Unani, siddha and Ayurveda. It has cure for inflammation, fungal infection, mutagenesis, carcinogenesis, hepatotoxicity, sterility, fibrosis, cholesterol, diabetes, ulcer, hypertension, viral diseases and coagulation problem. Now days it is used against Alzheimer's, Rheumatoid arthritis, bowel disease, Multiple sclerosis, HIV and Cataract (Jeevangi, 2013). Essential oils and curcuminoids are important bioactive compounds of Turmeric. 3-4 % of turmeric rhizome contains curcuminoids. While Curcumin I accounts for 94%, curcumin II accounts for 6 and III accounts for 0.3% (Chattopadhyay *et al.*, 2004). Curcumin is physically a crystalline orange yellowish powder which is water insoluble.

Remaining bioactive compounds includes which have lower oxygen scavenging potential including beta sitosterol, beta carotene, p-coumaric acid, terpinene, turmerin, camphene, turmeronola, vanillic acid, turmeronol-b, campsterol and syringic acid (Naz *et al.*, 2010). A safe, tolerable and non-poisonous dose of curcumin has been seen 12 g/day. FDA declared Turmeric and its active compounds as generally regarded as safe (Kumar *et al.*, 2011).

Isolation of curcumin from turmeric can be carried out by different method including alkaline solution, SFC, CSE and cold and hot percolation. High yield extractions solvents are acetones and alcohol. SFE has less penetration power into the turmeric so less damaging effect on bioactive ingredients. Green extraction technology (GET) is another name of (SFE) supercritical fluid extraction because oxygen is not present in this environment no oxygen means lesser oxidation of bioactive moieties (Sticher, 2008).

Quantification of curcumin in turmeric is done by spectrophotometer using color intensity. Individual curcuminoids and other metabolites of curcumin cannot efficiently characterized by this technique (Zhang *et al.*, 2009). HPLC with ultraviolet or visible detector at wavelength 245nm is best technique (Himesh *et al.*, 2008).

Hyperglycemia is a chronic malfunction of metabolism which can be distinguished by the raised glucose level of blood sometimes which is a due to defect in the secretion of the hormone insulin or sometimes defect in insulin action or both. Due to complications of small and large vessels it is linked with the high rate of disease and causalities. One of the familiar endocrine pathology prevalent both in developed and developing countries is DM and it has become one of the major health related problem in modern world. India is considered as diabetic capital of the world. in 2025 the hyperglycemic patients number will increase To 69.9 million which number in 2007 was 40.9 million. Globally, for every 10th second there is a chance 2 persons will develop diabetes and among them 1 person dies from diabetes related complications. There is enhanced risk of hypertension and atherogenic dyslipidemia in diabetes; therefore an increases prevalence of coronary artery disease, cardiac failure and stroke in diabetic (Kim *et al.*, 2013). Diabetes is one of the most common non-communicable pathological condition in the world (Zimmet *et al.*, 2001) about a population of 38.2 lac is suffering from the disease and by the year of 2035 this figure will become 55.2 lac (International Diabetes Federation (IDF 2014).

DM is a group of different ailments whose indication is high glucose level. Diabetes in human can be allocated into insulin-dependent diabetes, which is distinguished by juvenile onset, due to absolute insufficiency of insulin and by ability to formation of ketone bodies in unavailability of insulin treatment; and other type is noninsulin dependent diabetes, distinguished by mature onset, by difference in basic insulin levels, have a persistent relationship with obesity, and have a reduce active insulin response to intravenous glucose Richard *et al.*, (2000). There is lot of medications for diabetes is available but everything is unable to finish the spreading of this ailment. Modern medicines for treating diabetes have a lot of side effects that is why public is moving towards herbal or other methods of treatment because nature has a lower rate of bad effects. World health organization formulated a team for research on the good uses of plants who have curative properties for treating Diabetes Mellitus.

Insulin is a hormone which is responsible for maintaining normal blood glucose level by promoting glucose consumption by processes like glycolysis and

glycogenesis while it inhibits the glucose-producing processes like gluconeogenesis and glycogenolysis (Koolma *et al.*, 2005). Beta cell of the pancreas synthesized and secreted insulin to maintain glucose level of blood within a narrow range (Henquin, 2000). Excessive secretion of insulin can cause hypoglycemia while, under-secretion of insulin implicated in the development of diabetes mellitus (Henquin, 2000). Glucose is one of the most important stimulating agents for insulin production and secretion. An increase in glucose concentration of blood activate the beta cells of pancreas to take-up the C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, which phenomenon is carried out by an insulin dependent transporter protein named as (GLUT-2) (Thorens, 2001).

There are two main types of DM; DM type 1 & DM Type II. Type one can be characterized by decreased or no production of insulin which is caused by the destruction of pancreatic  $\beta$ -cell while type 2 diabetes occurs due to the combination of perimetric anti-insulin effects and pancreatic beta-cell secretion are inadequate (Motala *et al.*, 2003). These two major types of diabetes are characterized by high level of blood glucose, abnormal lipid and protein metabolism defines these two types of diabetes & its particular long-term complications including retinopathy, nephropathy and neurodegeneration. Hyperglycemia or high blood sugar level plays a vital function in causing diabetes mellitus and its related worse conditions.

Products from natural sources have attracted public and researchers because of its ability to manage the diabetes and its after effects because globally diabetes reached on an epidemic level. From curcuma longa plant turmeric is obtained which is famous due to its various uses in a Ayurvedic medicines. Curcumin ability to reduce many illnesses which includes heart diseases, swelling and sugar has been proved from many disease control studies. Due to its all of these effects curcumin nutraceutical importance has been increased. Curcumin availability in body is still an issue because hardly a small amount of active compound reaches the target tissue when given orally due to small residential time in gastric tract, little absorption and less stability of compound in gastrointestinal tract (Fang and Bhandari, 2010).

Enzyme present in gut abruptly converts the curcumin into vanillin and ferulic acid, in hepatic cells convert into sulfate and glucuronid to reduce the concentration (Anand *et al.*, 2007; Prasad *et al.*, 2014). A lot of new technologies and techniques have been developed to enhance the availability of the compound in human body. (Malacrida and Telis, 2011). At normal body state ROS produce as necessary part of reactions which are occurring in the body. If there is unavailability of balance between reactive oxygen species

and immune system of body it will cause oxidative stress which will lead toward life style related diseases. Ginger's antioxidant capability is 10 times less than turmeric, so turmeric is a best antioxidant spice (Ak and Glucin, 2008).

The main cause of death and disease around the world is metabolic syndrome like resistance to insulin, imbalance of lipids and hepatic steatosis. Bioactive compounds from natural plants claimed that they can balance the lipid metabolism and now they are claiming that it can control the hyperlipidemia and hyperlipidemia associated disorders Madkor *et al.*, 2011).

Turmeric powder, its compound curcumin & its derivatives and a lot of other extracts from the rhizomes found to have bioactive potential. A lot of therapeutic activities of turmeric are known. Curcumin has been 1st time isolated in 19th century in the form of rhizomes extracts of *C. longa* (Ishita *et al.*, 2004). The average intake of turmeric varies from 0.5 to 1.5g/day/person (Araaju *et al.*, 2001).

It has been seen that turmeric has an antidiabetic effect. Curcumin in a little amount prevent from galactose induced cataracts. Turmeric & curcumin reduced sugar level of blood in alloxan induced diabetes in rats (Arun *et al.*, 2002). It can also reduce complication of diabetes mellitus produced by advanced glycation end products. Curcumin makes better the resistance of insulin in diabetic patients because it increase the making of many genes which are responsible for insulin response due to the presence of peroxisome proliferator activated receptor gamma and its ligand binding function. It also trigger the (CI) entry into the cell for the regulation of insulin secretion when glucose level of plasma is high (Best *et al.*, 2007).

El-Bahr and Al- Azraqi (2014) in an experiment on rats find the link between the intake of curcumin and management of diabetes. This streptozotocin induced diabetic rats fed on diet which is based on curcumin and then the levels of their blood glucose measured. They found the results that dietary intake of curcumin is better for curing diabetes. So it's proved *curcuma longa* and its active compound curcumin administration to the rats suffering from diabetes decreased concentration of glucose level markedly compared to those diabetic rats who are not receiving these compounds; curcumin was more effective in reducing blood glucose than turmeric. Alloxan diabetic rats have high blood glucose level and also have high oxidative stress. In rat, that are treated with alloxan have elevated blood glucose levels. There was on supplementation with turmeric or curcumin show a significant fall in the blood glucose concentration of diabetic rats (Arun and Nalini 2002).

Diabetes Mellitus is basically a set of metabolic disorders affecting up to 23million people in the USA and about 250 million people globally, is distinguished by high blood glucose due to abnormality in insulin release and insulin action, or both of them. Curcumin longa L. has been generally used for a long time in local medicine for cure of a number of inflammatory conditions and other diseases. Turmeric yellow pigmented part has the medicinal properties (Yeh *et al.*, 2003).

### 2.1. Functional foods: An approach towards healthy life

Intake of junk food and bad dietary habits globally increase the production of free radicles and many other diseases which are dangerous for life. Economical and safe food based policies are the main concern of public health practitioners. A healthy life is always linked with good dietary recommendations, novel nutritional practices and good living patterns (Presscot, 2009). Foods which are designed have innate ability to aaugment from diseases and they look same alike commercially available foods. These products use on daily bases due to their linked health benefits. Intake of these designed foods has a greater trend in modern countries (Manjula and Suneetha, 2011). In these days we are in good position to formulate better functional foods which have the ability to fight with different diseases. These special foods are processed foods but these foods have added functional compounds that reduce the risk of many life threating aliments (Rajasekaran *et al.*, 2008; Yadav *et al.*, 2012).

Firstly, the advices made for healthy life style to use fewer amounts of fats and take a lot of vegetables and fruits which are rich in antioxidants. For better bodily performance food is always a feasible way (Ismail, 2006). That is the reason nutrition therapy due to its disease managing ability gain a lot of importance. These days commercially prepared special foods available which have ability to scavenge free radicles, cholesterol lowering and glucose lowering ability (Gorinstein *et al.*, 2006). Foods which are from plant origin contain different phytochemicals that has free radicles scavenging ability. Herbs and spices have functional compounds like vitamins, essential oils, antioxidants, minerals and fiber. For better antioxidant potential profile there is a need to concentrate these compounds (Tapsell *et al.*, 2006; Sarkaki *et al.*, 2013). The members of *Zingiberaceae* family contains those type of bioactive compounds that boost up the immune system by regulating the function of Glutathione, superoxide dismutase and glutathione peroxidase (Kunwar *et al.*, 2011; Hwang *et al.*, 2012). Hyperlipidemia and Diabetes are world's most common maladies and world has gain a strong disease transformation against these disorders. Spices should

be selected on the basis of research because these spices have ability to harmonies the immune system, reduce the chronic inflammation and have capability to scavenge the free radicles (Hwang *et al.*, 2012). The free radicle scavenging ability of turmeric affected by the difference in genotypes and difference in conditions at which crop is harvested.

### 2.2. Turmeric: An Introduction

Turmeric also called *Curcuma longa*, its family in Zinberaceae, production regions of turmeric in the tropical areas of South Asia, Pakistan, India, China and Bangladaish. The name *Curcuma Longa* is basically derived from Kirkum a Persian word meaning Saffron because both saffron and turmeric have bright yellow color. The second largest producer of turmeric is Pakistan while the number 1<sup>st</sup> producer and costumer of turmeric is India that is why turmeric in India named as Indian Saffron. In Pakistan per acre outcome of turmeric is low because of bad cultivation practices. It produces in Meerpur Khas, Kassor, Okara, Bannu and Lahore. Out of total production of turmeric more than 80% produce in Kasoor (Tahira *et al.*, 2010; Kiran *et al.*, 2013).

In societies technological populace use of pure oxidation preventing compounds from natural food sources from plants are increasing. It has been explained from different researches that regular use of pure oxidation preventive compounds in routine menus helps in prevention from the dysfunctions which are related to our way of living. But, the production of O<sub>2</sub> reacting compounds is a natural process, if balance between free radicals and antioxidants is destroyed; it will destroy the integrity of biological molecules (Lim and Han, 2016). Polyphenols are the main plant species present in plant foods such as fruits and vegetables, grains and spices (Sardar *et al.*, 2012). In addition, there is strong evidence to support the presence of botanicals in spices and their positive health effects (Srinivasan, 2005; Aggarwal *et al.*, 2009; Kunwar *et al.*, 2011). In addition to being a culinary ingredient. Basically, spices are seasoned with aromatic properties and are usually incorporated into traditional cooking (Suleria *et al.*, 2015). Among them, turmeric is widely used as a spice, cooking additives, medicine, spices, dyes and cosmetics, one of the important herbs (Lal, 2012) The active ingredients in these foods are associated with health promoters and disease prophylaxis (Suleria *et al.*, 2015). In this case, the fragrance is worth considering its antioxidant potential and is confirmed by various efficacy studies, particularly cinnamon, turmeric, clove and fennel (Kochhar, 2008; Suleria *et al.*, 2013).

In order to evaluate the antioxidant index of curcumin, various plant extracts were extracted using various organic solvents. Two processes are used on



the basis of their method of doing something, first is linked control the free electron and the second is rely on the peroxidation of lipids. The second one consist of ABTS, ferrous reducing antioxidant power, DPPH, and ferrous ion chelate (Suleria *et al.*, 2012; Moon and Shibamoto, 2009). Phytoremediation based on turmeric bioactive substances tends to improve the health of individuals by scavenging free radicals. The chemistry based investigation showed that  $\alpha$ ,  $\beta$ -unsaturated carbonyls of turmeric phenolic compound e.g. curcumin were indulge in nucleophiles balance. Since curcumin exhibits a structure which is diketonic, it is an interdependent b/w ketone & enol forms, these have a greater oxidation preventing capability (Kelkel *et al.*, 2010). The oxidation against function of bioactive compound of turmeric 'curcumin' is appreciated due to it's to its functionally active proportion; the betadiketone is taking the responsibility for the movement of free electrons. Or they interact with ROS or advance the gesture to a lot of targeting compounds Aggarwal and Sung (2009).

### 2.3. Chemical identification of compounds of Turmeric:

Turmeric composed of 3.5% minerals, 5.1% fat, 6.3% protein, 69.4% carbohydrates and 13.1% moisture, while the oil of turmeric contains almost 53 percent of Sesquiterpenes, 25% of zingiberene, 1% of cineol, 0.5% of borneol and 1% of phellandrene. It is also a fair source of fat soluble vitamin Retinol which is about 91mg and 100 g of its providing 310 kcal (Chattopadhyay *et al.*, 2004). The daily intake which consider safe by the World health organization is about 2.5mg/kg. B.W (Susikumar, 2001). Curcumin 71.5%, bisdemethoxycurcumin 9.1% and desmethoxycurcumin 19.4% are basically the non-evaporative fraction of turmeric. The chemical formula of Curcumin which is the basic compound of turmeric is  $C_{21}H_{20}O_5$  having molecular weight 368.38g (Akamine *et al.*, 2007). Dietary interruptions stress on the effective features of bioactive moieties as they apply good wellbeing sway towards different issue of metabolism. The bioactive compound of Turmeric has an outstanding antitumor-genesis effect. High performance liquid chromatography (HPLC) is the best method to separate curcumin from the turmeric. In order to ideally extract the active compound curcumin, there are three different types of conventional solvents were used, extraction was based on methanol based extraction, ethanol based and acetone based extraction for a time duration of thirty five minutes, fifty minutes & one hundred and sixty five minutes and at different breaks of supercritical carbon dioxide; 50, 100 and 150 minutes) used. (Ashraf *et al.*, 2016). In liver injury of Male mice a disease hepatitis which is caused by APAP recovery has been examined with curcumin in different

histology parameters by lowering the stress caused by oxidation, decreasing the swelling of liver and by the help of GSH restoring.

### 2.4. Disease preventing claims of *Curcuma Longa*

#### 2.4.1. Gastrointestinal Diseases:

Haridra's fresh fruit juice is considered a repellent. Curcumin reduces the adhesion of molecules and inflammatory cytokines by nuclear factor (NF) -  $\kappa$ B inhibition, thereby improving gastric injury induced by NSAIDs in rats. Curcumin administration can also improve gastric mucosal injury; reduce leukocyte adhesion, adhesive molecule within the cells & the formation of factor which is a tumor marker called TNF  $\alpha$ . Turmeric extract tablets significantly reduced irritable bowel syndrome morbidity and abdominal pain / discomfort scores at baseline and 8 weeks after treatment. IBS quality of life (QOL) has improved significantly.

#### 2.4.2. Diseases of Respiratory system:

Bronchitis patients given rhizome fresh juice. In rhinitis and cough boiled milk inside and mix in the internal given plank. In the case of catarrhal cough, sore throat and throat infection, the rhizome decoction is used for mouthwash, and the root tuber is slightly burnt and chewed. The chemical composition of turmeric has anti-asthmatic effect. In case of asthma and congestion, given the smoke of tobacco.

#### 2.4.3. Diseases of inflammation:

It is shown that curcumin can inhibit many different compounds which can cause swelling, including phospholipase, lipoxygenase, COX-2, leukotriene, prostaglandin, NO, thromboxanes, elastase, MCP-1, IIP, TNF, collagenase and interleukin. Studies have shown that bisdimethylcurcumin (BDC) is more effective as an antiinflammatory agent, as evidenced by inhibition of TNF-induced activation of NF- $\kappa$ B, as an antiproliferative agent, and more efficiently inducing reactive oxygen species (ROS). The Hispolon analogue, which lacks an aromatic unit relative to curcumin, also exhibits enhanced anti-inflammatory and antiproliferative activity. The beneficial effect of curcumin (antiinflammatory compound) in sepsis appears to be of PPAR- $\gamma$ , leading to inhibition of proinflammation, cytokines, TNF- $\alpha$  expression and release.

#### 2.4.4. Antioxidant potential of Turmeric

About 75 to 80 % of total curcuminoids present in the turmeric is composed of curcumin. Curcumin has the ability to lessen the formation of  $H_2O_2$ , Nitrile radicles and superoxide in this way it stops the damage to erythrocytes. Free radicles scavenging ability of turmeric is hundred times more than tocopherols and ascorbic acid. It breaks the bond in conjugated structures of methoxylated phenolic and  $\beta$ -diketone groups by scavenging the free radicles (Eybl

et al., 2006). Different varieties of turmeric contain different amount of curcumin depending upon the growing conditions etc. Curcumin has antioxidant potential in two different ways: firstly its ability depends upon the free radicle scavenging power and second depends upon the lipid peroxidation (Moon and Shibamoto, 2009). The antioxidant ability of curcumin which is assessed by iron chelation assay and DPPH markedly decreased by drought conditions. The bioactive compound of turmeric named as curcumin is very sensitive to high temperatures which results in deterioration and evaporation which results in the loss of curcumin (Cousins et al., 2007). Polyphenols potential of reduction against free radicles can be better quantified by DPPH & ABTS methods.

#### **2.4.5. Malfunctioning of cardiovascular system:**

Curcumin antioxidants can also prevent cholesterol damage, which helps to prevent constriction of blood vessels. Realistically the capability of oxidation preventers to reduce electrons with zero charge in turmeric is same to the ascorbic acid and tocopherol. Since the antioxidant activity of curcumin is stable to heat, it can be beneficial to use spices even in cooking. Animal studies have shown that curcumin decreases the level of triglycerides & cholesterol, and other fat circulating in blood enhance the chance of occurring heart disease. In the recent atherosclerosis study, mice were nourished a standard American eating regimen, rich in refined sugars and immersed fats, however with low fiber content. Be that as it may, a few mice got this eating routine in addition to turmeric blended with their sustenance. Four months after these weight control plans, blood vessel impediment of mice sustained turmeric mice without turmeric mice was 20% not as much as that of mice without turmeric. In another investigation, rabbits bolstered turmeric in addition to diets intended to cause atherosclerosis. A few hazard factors for the ailment are enhanced, including cholesterol diminishment, triglycerides and free radical harm.

#### **2.4.6. Protective effect on liver cells:**

Rhizome powder mixed with amla juice for jaundice. Corriiyum (Anjana) with Haridra, Gairika and Amalaki (*Emblca officinalis*) cure jaundice. Curcumin is the most common antioxidant component of turmeric and is reported to increase the natural death of diseased liver cells, that was the curative effect of curcumin lowering the inflammatory response and fibrogenesis of the liver. When oral doses of two hundred and fifty and five hundred mille gram per kilogram, ethanol extract of the rhubarb rhubarb showed significant liver protection, and the shielding response was not independent. The main ingredients in turmeric curcumin squeeze are flavonoids curcumin & many other evaporative oils,

including piperine, atrazine, & cynthine. This protective effect by turmeric on the liver is due to the capability of curcumin to work as oxidation preventive molecule or its ability to hunt the free electrons process, along with that they have the capability the ability to indirectly enhance the levels of glutathione, tin this way contributing to liver detox function. Turmeric oil and the active compound curcumin show a strong anti-inflammatory effect.

#### **2.4.7. Effect on nervous system:**

Ginger butter significantly reduces the adverse effects of ischemia by reducing nitrosation and oxidative stress. Ischemia caused by mitochondrial membrane potential disintegration followed by caspase activation led to sequence induced apoptosis, turmeric oil significantly reversed. Therefore, there is evidence that Zedoary turmeric oil as a neuroprotective effect of high efficiency, with the prevention of ischemic brain damage excellent treatment window.

#### **2.4.8. Alzheimer's disease:**

Curcumin reduces plaque deposition when curcumin feeds older mice with late plaque deposits similar to Alzheimer's disease. It reduces oxidative destruction and reverses pathology of amyloid in a neurogenic disease called Alzheimer's disease transgenic mice. Symptoms of swelling and oxidation of this problem are also a strong antioxidant and anti-inflammatory properties of curcumin. Chemical Protection Activity: Curcumin Activates DDR (DNA Damage Reaction), providing the opportunity and reason for the clinical application of these nutrient drugs in chemically preventing prostate cancer. Exposure to bile acids in esophageal epithelial cells in the chemical protective effect; curcumin reversal of bile acid inhibition of SOD-1 gene expression, but also inhibit COX-2 gene expression of bile acid induced. Curcumin has demonstrated these chemical prophylactic properties in cell culture, animal models and human investigations.

#### **2.4.9. Tumor preventing activity:**

Curcumin has been found to have anticancer activity by its various biological pathways involved in genesis of mutation, activation of cancer causing gene, regulating the cell cycle, natural cell death, formation of tumor and movement of cancer cell from one place to other.

#### **2.5. Pathophysiology of Diabetes**

Hyperglycemia or DM is basically a group of diseases consisting of hyperglycemia-defined syndromes; conversion of fat, amino acids and carbohydrate metabolism; and also increases the chance of more complications (Davis, 2006). Because of the rapid changes in the ecosphere and the rapid shift in lifestyles from the east to the Europe, the chances of diabetes are greater (Zimmet et al., 2001).

for this reason seeking for native origins glucosidase blockers with fewer after effects get more attention in the world of science. In patients with NIDDM, glucosidase was administered to the posterior vitamin sugar level blocker drug normalization (Gin and Rigalleau 2000). In the high blood sugar population, glucosidase acrobases and miglitol blockers, which are commonly used to control postprandial hyperglycemia, cause many other sequelae (Fujisawa et al., 2005); for this reason, seeking natural origin has less effect. Of the glucosidase blockers in the scientific world to get more attention.

Kumar *et al.*, (2010). have studied new functions of plants as glucosidase inhibitor blockers. *Curcuma Longa* is recommended for the treatment of hyperglycemia in the conventional treatment of India and its associated alignments (Chattopadhyay et al., 2004). Many studies have established the ability to resist hyperglycemia by blocking the glucosidase function (Kumar et al, 2005; Srinivasan 2005).

## 2.6. Antidiabetic effect of Turmeric

To survey the adequacy of *Curcuma Longa* in postponing the improvement of NIDDM in the prediabetes populace. This randomized, double-blind, pseudo-treatment control trial included subjects with pre-diabetes criteria (n = 240). All subjects were randomized to curcumin or fake drug for 9 months. After curcumin administration a survey was performed to check the difference in the capacity of  $\beta$ -cell, insulin resistance, adiponectin and among these other different parameters have been also checked with medications for a time period of 3, 6 and 9 months. If an adequate dose of curcumin was given to the prediabetes who are in a long run towards diabetes curcumin will minimize the chances of that person to become diabetic. Also, the curcumin treatment seemed to enhance general capacity of  $\beta$ -cells, with exceptionally minor unfavorable impacts. In this way, this review exhibited that the curcumin intercession in a prediabetic populace might be gainful (Chuengsamarn *et al.*, 2012).

Turmeric root powder is exceptionally valuable with Amra squeeze and nectar (Diabetes). The impact of 6g turmeric expanded postprandial serum insulin levels, yet did not seem to influence blood glucose levels or GIs in sound subjects. The outcomes demonstrated that turmeric may affect insulin discharge. The dynamic guideline of turmeric rhizome The curcumin decreases lipid peroxidation by keeping up larger amounts of cell reinforcement compounds, for example, superoxide dismutase, catalase and glutathione peroxidase. The cell reinforcement properties of curcumin will be curcumin and its three subordinates (dimethoxy curcumin, dideoxyethoxy curcumin and diacetyl curcumin). The revelation of the logical framework demonstrates that the

antipyretic, hypolipidemic and hepatoprotective impacts of the long-acting stop dried root powder of turmeric broke down in drain can be utilized as a high potential compelling and safe antidiabetic dietary supplement. It is realized that turmeric can contain curcumin, glycosides, terpenoids and flavonoids. The most extreme inhibitory impact of human pancreatic amylase (HPA) was gotten with the concentrate of the isopropyl alcohol and the extract of acetone. This inhibition of HPA resulted in a decrease in starch hydrolysis leading to a decrease in glucose levels.

(Jeevangi *et al.*, 2007) studied to assess the anti hyperglycemic role of ethanolic extract of Rhizomes of Turmeric in diabetic rats in which diabetes is induced by alloxan and check the comparison with qualitative anti hyperglycemic agent Pioglitazone. Diabetes mellitus is induced by using Alloxan monohydrate in albino rats by using the dose of 120mg/kg i.p and anti hyperglycemic effect of turmeric was studied by following study design. The participants were randomized in 6 groups and each group contains 6 rats. It was a 28 days study and drugs were administered orally once a day. Their Blood glucose levels were measured at 1, 3, 5, 7 hrs. in (acute study) while in chronic study blood glucose were measured at 7, 14, 21, 28 days. The animal health and body weights of the rats in every groups were recorded on weekly basis recorded cautiously. It has been seen that the Ethanolic extract of turmeric shown marked fall on the blood levels of glucose levels on seventh, fourteenth, twentyfirst and twentyeighth day in hyperglycemic mouse however single dose has no marked decrease in blood glucose levels after first hour, third hour, fifth hour and seventh hour. in this study it is revealed that turmeric has anti-hyperglycemic potential which can be used to treat hyperglycemic patients.

The advantageous impact of spent turmeric (*Curcuma longa*) on diabetic status was considered in streptozotocin-instigated diabetic rats. Diabetic rats shed pounds yet body weights were enhanced by sustaining spent turmeric. *Curcuma Longa* change the list of pee sugar level and pee volume about thirty percent. Glucose level before breakfast demonstrated a 18% change with spent turmeric nourishing to rats suffering from diabetes (Kumar *et al.*, 2005). The present investigations propose that curcumin and turmeric treatment seem to have countered the hyperglycemia-actuated oxidative anxiety, in light of the fact that there was an inversion of changes as for lipid peroxidation, lessened glutathione, protein carbonyl substance and exercises of cell reinforcement chemicals in a critical way. Likewise, treatment with turmeric or curcumin seems to have limited osmotic pressure, as surveyed by polyol pathway proteins. Most imperative, total and insolubilization of proteins

of lense because of hyperglycemia was avoided by turmeric and curcumin. Turmeric was more viable than it's relating levels of curcumin (Suryanarayana *et al.*, 2005).

Suryanarayana *et al.*, (2007) studied that there is expanding proof that difficulties identified with diabetes are related with expanded oxidative anxiety. Curcumin, a dynamic guideline of turmeric, has a few natural properties, including cell reinforcement movement. The defensive impact of curcumin and turmeric on streptozotocin (STZ)- prompted oxidative worry in different tissues of rats was contemplated. Three-month-old Wistar-NIN rats were made diabetic by infusing STZ (35 mg/kg body weight) intraperitoneally and nourished either just the AIN-93 eat less or the AIN-93 consume less calories containing 0.002% or 0.01% curcumin or 0.5% turmeric for a time of two months. Following two months the levels of oxidative anxiety parameters and action of cell reinforcement catalysts were resolved in different tissues. STZ-instigated hyperglycemia brought about expanded lipid peroxidation and protein carbonyls in red platelets and different tissues and adjusted cell reinforcement catalyst exercises. Strangely, encouraging curcumin and turmeric to the diabetic rats controlled oxidative worry by restraining the expansion in TBARS and protein carbonyls and turning around modified cell reinforcement catalyst exercises without altering the hyperglycemic state in a large portion of the tissues. Turmeric and curcumin seem, by all accounts, to be beneficial in avoiding diabetes-actuated oxidative anxiety in rats in spite of unaltered hyperglycemic status.

In another study a unique Curcumin derivative which is water soluble (NCD) has been evolved to cope up small in vivo biological availability of Curcumin and to check its curative outcome in rats with hyperglycemia. Novel water soluble curcumin derivative or pure Curcumin provision to diabetic rats markedly decreased the blood glucose levels and it also positively improve the plasma level of insulin, in comparison with the hyperglycemic group and it has been seen that NCD effect was greater than Curcumin. On plasma glucose levels administration of oral NCD has no effect in the control group, but plasma insulin level markedly increased in the control group. While cure of hyperglycemic rats be presented with oral NCD with HO-1 inhibitor zinc protoporphyrin significantly improve plasma glucose level and show marked drop in insulin levels, when comparison is made with the hyperglycemic group who are only presented with oral NCD. Provision of oral NCD or pure Curcumin markedly enhanced the HO-1 assertion level in pancreatic tissues of the hyperglycemic group, in comparison with controls. It was recommended that the hypoglycemic potential of Curcumin might be

arbitrate through the expression of HO-1 (Son *et al.*, 2013). Kim *et al.*, (2009) demonstrated that Curcumin as dynamic anti-oxidant and inflammation inhibitory substance. Evidences suggested that curcumin have a effective role in animal models of hyperglycemia, both by decreasing glucose levels of blood and by reducing the long-term problems of diabetes. Jianguo and Anping (2011) in a study summarized that hyperglycemia, e.g. glucose at 450 mg/dl, induced hepatic stellate cells activation hyperglycemia in vitro, which may be due to the elevation intracellular glucose level. This process consist two-steps. The first part happened with after the administration of glucose to cells at 450 mg/dl within 30 mins. The second step occurred after 3 hrs. Curcumin rapidly stopped the membrane transfer of GLUT2 by intruding the p38 MAPK signaling process and in this way masked the gene expression of GLUT2 by bracing PPAR activity and regulate oxidative stress, combinedly leading to the removal of the two-step role of diabetes in increasing the level of intracellular glucose and stop HSC activation in vitro.

Studies demonstrated on hyperglycemic rats for 7 weeks administrated by high-fat diet with streptozotocin (30 mg/kg BW) were fed on a meal which consists of 50, 150, or 250 mg/kg BW curcumin. Depending on dose curcumin can reduce lipids and glucose level of plasma and 150 mg/kg BW shown to have a marked effect. Curcumin supplementation can reduce glucose and insulin tolerance. Curcumin make better the muscular insulin resistance by speed up the oxidation of fats and glucose, which is bring about through LKB1-AMPK pathway (Na *et al.*, 2011). DM portrayed raised level of sugar in vital fluid in light of fatty sustenances i.e. regularly overseen the discharge of hormone insulin from the gland pancreas discharge. Global wellbeing association assessed that about 33.6 lac individuals on planet due to casualty of this disease DM in a year of 2030. That will disturbing & we should have thought about it and take some measures ahead it goes out of control. DM was characterized on the premise of 3 cells usefulness b/w sort one; insulin subordinate DM and sort 2; which is noninsulin subordinate diabetes mellitus. DM is a sickness which regularly happens in light of situation of high blood glucose level (WHO, 2006). The DM is a disorder of endocrine secretions, disturbing & affect contrarily on CVDs wellbeing. Definitely, ineffective cover up on the glucose level of vital fluid controlled blood glucose level prompts the advancement of confusions of diabetes (Laitinen *et al.*, 2009). Thirty three percent of every single patient of diabetes is persuaded to receive eat less carbs based treatments. Among, utilization of *curcuma longa* in different patterns of diet is extremely normal. The sugar lowering capability of *curcuma longa* is credited



to its curcumin content, managing six carbon kinase and G6P dehydrogenase. These compounds included in hexosugar by adding phosphate in the glucose in the process of glycolysis use either by phosphorylation to enter in glycolytic pathway or by keeping up typical amount of ATP containing compounds NADPH (Amin *et al.*, 2015; Dai and Kamel, 2014). The comparative impact was seen on alloxan incited hyperglycemic mouse furnished with curcuma longa and in form of pills the curcumin ingestion and intake of less carbs for a time period of twenty one days. This type of medications radically diminished G6P while vitally improved exercises of hexokinases enzymes of liver and serum, phosphate glucose & lactate dehydrogenase. In any case, turmeric was less effective than the supplementation of curcumin; it demonstrated extra effective even in low measurements. In diabetic condition, expanded level of corrosive phosphatase and antacid phosphatase brings about expanded spillage from cells that are facing the phase of death however curcuma longa phenolic compounds admissions lessened in serum level Aziz *et al.*, (2013).

In like manner, a researcher contemplated glucose lowering impact of turmeric extracted by ethanol turmeric remove on male hyperglycemic mouse Santoshkumar *et al.*, (2013). The critical effect was more than 49.92% in glucose level of blood was seen regarding control gathering. Decisively, they affirmed turmeric as an enhancing specialist for hyperglycemia. There are logical confirmations for the utilization of different blends of flavors alongside hostile to diabetic medications at least dosage to treat hyperglycemic condition. In like manner, Srinivasan, (2004) assessed joined utilization of onion, fenugreek and turmeric powder on the hyperglycemic rats. Contingent upon the test information, it was gathered that day by day admission of 50 g onion, 25-50 g fenugreek and 1 g turmeric are effective dietary incorporations to oversee diabetes and related confusions. The glucose controlling impact is credited to bioactive moieties that upgrade insulin emission and glucose ingestion. This is all around reported that curcumin intercession lessens the onset of sort II diabetes in pre-diabetic patient. In a randomized controlled trial, 240 individuals were furnished with either fake treatment or curcumin supplemented slim down for 9 months to survey movement of diabetes. Amid the dietary interruption time frame, alterations in mitigating adiponectin, insulin resistance and (3-cell usefulness were recorded at time interim of 0, 3, 6 and 9 months. The results demonstrated that curcumin diminishes insulin resistance by actuating receptors on cell surface and lessening passing of  $\beta$ -cells. The critical augmentation was found in homeostasis display for [3-cell's (HOMA-p) of curcumin treated

assemble speaking to insulin usefulness Similarity likewise watched for adiponectin the event of diabetic inconveniences. In any case, insulin resistance (HOMA-1R) diminished up to 20.29% attributable to solid p-celis work (Chuengsamarn *et al.*, 2012). Flavors don't add to supplement make up as they are devoured in minute amount thus considered for enhancing or shading qualities. Notwithstanding, considering the wellbeing advancing impacts, these sustenance aides have accomplished the status of "nutraceuticals". In such manner, curcumin is in charge of restorative impacts against irritation, diabetes, osteoarthritis and cardiovascular infections. It is outlined that turmeric is one of the essential flavors for wellbeing advancement and ailment avoidance. Curcumin averts galactose-prompted formation of cataracts at low doses. Both turmeric and curcumin diminish glucose level in alloxan-prompted diabetes in rat. Curcumin additionally diminishes propelled glycation end products induced inconveniences in diabetes mellitus (Chattopadhyay *et al.*, 2004).

In the conventional arrangement of prescription, Ayurveda, a few flavors and herbs are thought to have restorative properties. Among the flavors, turmeric rhizomes (*Curcuma longa*.) are utilized as seasoning and shading operators in the Indian eating routine ordinary. In this exploration, we contemplated the impact of turmeric and its dynamic rule, curcumin, on diabetes mellitus in a rodent study. Alloxan was utilized to prompt diabetes. Organization of turmeric or curcumin to diabetic rats lessened the glucose, Hb and glycosylated hemoglobin levels essentially. Turmeric and curcumin supplementation additionally lessened the oxidative anxiety experienced by the diabetic rats. This was exhibited by the lower levels of TBARS (thiobarbituric corrosive responsive substances), which may have been because of the diminished flood of glucose into the polyol pathway prompting an expanded NADPH/NADP proportion and raised movement of the intense antioxidant compound GPx. Additionally, the action of SDH (sorbitol dehydrogenase), which catalyzes the transformation of sorbitol to fructose, was brought down fundamentally on treatment with turmeric or curcumin. These outcomes likewise seemed to uncover that curcumin was more compelling in lessening diabetes mellitus related changes than turmeric (Arun & Nalini 2004).

A study was conducted by Sukandar *et al.*, (2012). The point of this examination was to analyze viability and wellbeing of *Allium Curcuma* with glibenclamide in sort 2 diabetes mellitus with or without dyslipidemia. Thirty five patients were selected and randomized into 2 bunches for 14 weeks treatment and appraisal. One gathering got think about medication, three times two cases containing 200 mg

turmeric and 200 mg allium remove for each day. The other gathering got 1 case of 5 mg glibenclamide as standard medication every day. Following 14 weeks of treatment patients with allium curcuma treatment indicated huge diminished in fasting blood glucose (192.76 versus 141.71 mg/dL) and 2 hours post-prandial blood glucose (295.35 versus 204.35 mg/dL). HbA1C level was also significantly diminished. No distinction was found in circulatory strain, hematology profile, liver and kidney capacity of both gatherings. All in all, allium curcuma can possibly be utilized as antidiabetic specialist.

Diminishment of Blood Glucose Level by Curcumin AMPK pathway intervenes the administrative impact of curcumin on lipid and glucose oxidation and use, restrains hepatic gluconeogenesis and glycogenolysis: Inhibits hepatic G6Pase and phosphoenolpyruvate carboxykinase (PEPCK) action. Expands phosphorylation of AMP kinase (which prompts phosphorylation of GEF (GLUT4 upgrade calculate), Represses PDK4 expression, Decreases glycogen blend, Lessens hepatic glucose production, Increases PPAR ligand-restricting movement, Builds phosphorylation of AKT (PKB), insulin receptor and IRS-1, Declines PTP1B and HOMA-IR, Expands HOMA and enhances cell function, Stimulates insulin emission from pancreatic tissues, Increment GLUT4 and animates of glucose uptake, Reduces the oxidative anxiety and fiery state, Expands the adiponectin levels, Decreases HbA1c and blood glucosylation toward enhancing the insulin affectability and glucose control in skeletal muscle. Curcumin can decrease blood glucose and HbA1c level by lessening in hepatic glucose creation and glycogen combination and incitement of glucose take-up by expanding GLUT4, GLUT2 and GLUT3 quality expressions, expanding initiation of AMP kinase, advancing PPAR  $\gamma$  ligand-restricting action, stifling hyperglycemia-prompted fiery state, incitement of insulin emission from pancreatic tissues, change in pancreatic cell work, Increasing phosphorylation of AKT (PKB), insulin receptor  $\beta$  and diminishment of insulin resistance. In human clinical trials directed on diabetic and pre diabetic patients, glucose bringing down impact of turmeric and curcumin have been watched. In any case, no impact was found in patients with typical standard levels of glucose. More investigations assessing the impacts of curcumin on hyperglycemic state and insulin resistance in related illnesses, for example, diabetes are prescribed (Ghorbani *et al.*, 2014).

The target of the present examination was to research the antidiabetic impacts of Turmeric (*Curcuma longa*) and Black cumin seed (*Nigella sativa*) either alone or in blend on blood glucose focus, body weight, water and sustenance allow and chose

biochemical parameters of streptozotocin (STZ) prompted diabetic rats. Thirty five sound grown-up pale skinned person rats continued standard proportion, got water not indispensable and isolated into five gatherings (7 rats in each). Rats of first and second gatherings were non diabetic and diabetic separately. Rats of 3-5 bunches were diabetic and got Turmeric (1g/kg b.wt.), Black cumin seed (2g/kg b.wt.), half measurement of dark cumin seed and Turmeric as a blend, individually. All medicines were orally managed by intra-gastric intubations once per day for a month and a half. Results: The present examination uncovered that, STZ exploratory diabetes incited critical rise of glucose level, water and sustenance admission, TAG and aggregate cholesterol level with noteworthy diminishment of body weight pick up of the influenced rats. Be that as it may, dietary supplementation of either Turmeric or Black cumin seed essentially ( $P \leq 0.05$ ) adjusted the estimations of these parameters close to control levels. What's more, liver and kidney work were irritated in STZ-diabetic rats and reestablished at whatever point treated with the analyzed therapeutic plants. Conclusion: The present investigation can presumed that, dietary supplementation of either Turmeric or Black seed to diabetic rats were compelling in lessening blood glucose, water and sustenance admission, TAG and cholesterol joined by an expansion in body weight pick up. With respect to Body weight pick up, nourishment consumption, water admission, blood glucose level and TAG level, Turmeric was more viable than dark cumin seed and blend of both plants (El Bahr and Al-Azraqi 2014).

The curcumin intercession essentially lessened heartbeat wave speed, expanded level of serum adiponectin and diminished level of leptin. These outcomes are related with decreased levels of homeostasis demonstrate appraisal insulin resistance, triglyceride, uric corrosive, instinctive fat and aggregate muscle to fat ratio ratios. In rundown, a 6-month curcumin intercession in sort 2 diabetic populace brought down the atherogenic dangers. What's more, the concentrate enhanced significant metabolic profiles in this high-hazard populace (Chuengsamarn *et al.*, 2013).

A study by Appendino *et al.*, (2010) The point of the present examination was to assess the change of diabetic micro angiopathy in patients enduring from this condition since no less than five years, and whose ailment was overseen without insulin. Curcumin, the orange color agent of turmeric, has as of late gotten expanding consideration due to its cancer prevention properties, intervened by both direct oxygen radical extinguishing abilities. This angle, consolidated with the advantageous consequences for endothelial work and on tissue and plasma incendiary status, makes

curcumin possibly helpful for the administration of diabetic microangiopathy. To additionally assess this, Meriva, a lecithinized definition of curcumin, was directed at the dose of two tablets/day (1 g Meriva/day) to 25 diabetic patients for four weeks. A practically identical gathering of subjects took after the most ideal administration for this sort of patients.

Results. All subjects in the treatment and control aggregate finished the subsequent period; there were no dropouts. In the treatment gathering, at four weeks, microcirculatory and clinical assessments showed a reduction in skin flux ( $P<0.05$ ) at the surface of the foot, a discovering indicative of a change in microangiopathy, the flux being by and large expanded in patients influenced by diabetic microangiopathy. Likewise, a critical diminish in the edema score ( $P<0.05$ ) and a relating change in the venoarteriolar reaction ( $P<0.05$ ) were watched. The PO<sub>2</sub> expanded at four weeks ( $P<0.05$ ), of course from a superior oxygen dissemination into the skin due to the diminished edema. These discoveries were available taking all things together subjects utilizing Meriva, while no clinical or microcirculatory impacts were seen in the control gathering.

Meriva was, when all is said in done, very much endured, and these preparatory finding propose the convenience of this curcumin detailing for the administration of diabetic microangiopathy, opening a window of chances to be assessed in more delayed and bigger examinations. The sub-atomic components required in the advantageous impacts of curcumin on microcirculation furthermore, edema are additionally worth examination.

In another trail, patients were made a request to keep up their routine eating regimen, way of life, and unique medication treatment amid curcuminoids supplementation. We watched a lessening in serum FFAs and triglycerides, and also fasting blood glucose, HbA1c (%) and HOMA-IR in sort 2 diabetic patients supplemented with curcuminoids. Decreasing serum FFAs has been recognized to be a remedial technique in the treatment of insulin resistance and diabetes. Some against diabetic medications apply their belongings, at any rate to some extent, by diminishing the convergence of serum FFAs. In this investigation, we hypothesize that the counter diabetic impact of curcuminoids is most likely, at any rate to some extent, because of the watched diminish in serum FFAs. Serum triglycerides are a noteworthy wellspring of FFAs for muscles and fat tissues. Serum LPL is a key protein that hydrolyzes coursing triglycerides, prompting the era of FFAs. Serum LPL movement is fundamentally lower in diabetic patients and demonstrates a negative connection with triglycerides focus. Overexpression of human LPL can shield diabetic transgenic mice from diabetic

hypertriglyceridemia Increased serum LPL movement in curcuminoids-supplemented patients, as seen in this investigation, raises the likelihood that the abatement in serum triglycerides by curcuminoids are, in any event mostly, because of expanded triglyceride hydrolysis by LPL. Likewise, curcuminoids have been found to diminish liver triglyceride focuses in high-fat-prompted creature models. Along these lines, we can't prohibit the likelihood that the lessening in serum triglycerides by curcuminoids is because of diminished triglyceride blend and emission by the liver.

Regarding serum free fatty acids the patients who are supplemented with curcumin have an improvement in their free fatty acids level of serum. In this way curcumin encourage serum free fatty acids take up and use by tissues. To start with, our past examination demonstrated that curcumin had an against diabetic impact by advancing unsaturated fat take-up and  $\beta$ -oxidation and hindering unsaturated fat blend in the diabetic mice skeletal muscle. Besides, curcumin were likewise appeared to expand unsaturated fat  $\beta$ -oxidation and restrain unsaturated fat union in the C57/BL mice fatty tissues encouraged on a eating routine which based on high fat diet. As a result of the liver, dietary curcumin supplements appear to generally reduce liver triacylglycerol, cholesterol focus and increase hepatic acyl-CoA oxidase activity, which is the main synergistic effect of rat peroxisomal unsaturated fatty beta-oxidation, sustained high Fat diet program. The advancement of unsaturated fat oxidation in tissues by curcuminoids causes the diminishing in free fatty acids.

Concerning alteration in the profile of serum free fatty acids after the supplementation of curcuminoids the level of 16 carbon containing palmitic acid, Oleic acid at the ratio of carbon 18 ratio 1 and 18 carbon containing stearic acid and  $\omega 6$  linoleic acid unsaturation at two 2 points in a chain of 18 carbon fundamentally diminished, which has been observed to be decidedly corresponded with sort 2 diabetes. Curcuminoids supplementation will lessen the free fatty acids and IR. Additionally investigation of the component by which curcuminoids influence unsaturated fat digestion in diabetes is required. Different systems are likewise presumably included in the watched impacts of curcuminoids, despite the fact that we didn't inspect these parameters specifically in the present investigation.

For example, poorly poor quality of the stimulus is often associated with obesity and stubborn metabolic disorders. Stimulation is a key factor in improving insulin resistance and the effect of curcumin on diabetes mellitus is expected to show an increase in concealment in past examinations. Curcumin limits the rise in the expression level of NF-

kB and JNK marker pathways play a role in mice that promote high-fat diets. It is discovered that curcumin fundamentally lessened penetration of white fat tissue, expanded fat tissue adiponectin generation, and diminished the nuclear factor kappa B movement of hepatic tissues & biomarkers of hepatic irritation in experimental diabetic rats. These bioactive compounds have the ability to down regulate the glucose level of blood in non-insulin dependent diabetes mellitus induced rats by PPAR $\gamma$  initiation. Aggregately, these bioactive compounds of turmeric have an insulin flagging and diabetes preventive effect. Moreover, curcumin may enhance  $\beta$  cell work by hostile to oxidation and mitigating impacts, as curcumin is beneficial against oxidative stress and it has the free radicles scavenging power, which is in charge of insulin production cell's harm and brokenness. Expanded free fatty acids can repress the concealment of liver generation of glucose by insulin. In this examination, the possibility of lowering serum FFA and prolonged insulin through curcumin may lack the camouflage of the hepatic glucose age of insulin.

According to the WHO/FAO a Joint Expert Committee on Food Additives (JECFA), curcumin is used as a food coloring pigment and is used in the range of 5 to 500 mg / kg, depending on the food category. The required amount of curcumin for our study cannot be simply fulfilled by adding extra turmeric in food. Along with that adding extra amount of these spices will change the color and the taste of your meal, and a lot of people don't like the curcuminoids color and taste. That is why we recommended the patients to take the supplements of curcuminoids. dose of curcumin administered in our study is not easy to achieve by simply adding more spices to the diet.

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