WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 7.523
Volume 6, Issue 11, 331-341. Review Article ISSN 2277– 7105

CARDIOPROTECTIVE EFFECT OF SESAME OIL: A REVIEW

Lakshmanan Vennila*

Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, Annamalainagar, Tamilnadu, India.

Article Received on
28 July 2017,

Revised on 19 August 2017,
Accepted on 12 Sept. 2017

DOI: 10.20959/wjpr201711-9607

***Corresponding Author**
Dr. Lakshmanan Vennila
Department of Biochemistry and Biotechnology, Faculty of Science, Annamalai University, Annamalainagar, Tamilnadu, India.

ABSTRACT

Cardiovascular diseases (CVDs) and their risk factors are major contributors to global morbidity and mortality. CVDs are associated with oxidative stress, leading to an increased production of reactive oxygen species (ROS), including superoxide radical, hydrogen peroxide, and hydroxyl radical or reduction of antioxidant defense system. These reactive species attack biomolecules such as lipids, DNA, and proteins enhancing the previously established tissue damage, as well as triggering cell death pathways. Hypercholesterolemia, high concentration of low-density lipoprotein cholesterol (LDL-C), very low density lipoprotein-cholesterol (VLDL-C), hypertriglyceridemia and low high-density lipoprotein (HDL-C) are also the independent risk factors for atherosclerotic CVDs. In this review, we propose a systematic approach to the cardioprotective effect of sesame oil that could offer a novel therapeutic opportunity against this oxidative tissue damage. Sesame seeds and oil have long been categorized as traditional health food in India and other East Asian countries and it is one of the major cooking oil used in human diet. Sesame oil supplementation decreased serum TC, LDL-C and lipid peroxidation, and increased antioxidant status in hyperlipidemic patients. Sesame oil, in comparison to other dietary oils such as ground nut and sunflower, also offers better protection against increased BP, hyperlipidemia and lipid peroxidation by increasing enzymatic and non-enzymatic antioxidants. This review addresses the recent findings of cardioprotective potentials of sesame oil.

KEYWORDS: cholesterol, blood pressure (BP), oxidative stress, antioxidants and hyperlipidemia

INTRODUCTION

CVDs encompass any medical conditions related to the heart and blood vessels. Majority of CVDs conditions are caused by plaque buildup in the walls of the arteries. Plaque is made up of various substances that are present within the blood. These include cholesterol, fat, cellular waste, calcium and fibrin. When plaque is built up on the walls of the arteries, it reduces the blood flow to and from the heart. This condition or a complete blockage of the artery due to a ruptured plaque wall can result in heart attack or stroke, and even death. Major CVDs includes ischemic heart disease mainly angina pectoris, atherosclerosis, hyperlipidemia, cardiac arrthymia and hypertension. (Donnell and Nabel, 2011). CVDs are the major health problem of highly developed as well as developing countries of the world. In 2002 it was estimated that 29 percent of deaths worldwide (16.7 million deaths) were due to CVDs and that 43 percent of global morbidity and mortality, was caused by CVDs (WHO, 2002). By 2030 more than 23.3 million people will die annually from CVDs (WHO, 2014). CVDs are also the leading cause of death in India and it cause 3 million deaths per year, accounting for 25% of all mortality. Living a sedentary (inactive) lifestyle has consistently been one of the risk factors for heart disease. Also at risk are people with diabetes, high blood cholesterol levels, high blood pressure BP) and individuals who have family history of the disease (Salahuddin and Frossard, 2004). The risk of getting this disease also increases with age, and is more prevalent among smokers than non-smokers.

This review aims to illustrate the cardiopretective role of sesame oil. Sesame oil is also known as gingelly oil and it obtained from the seeds of *Sesamum indicum* L. belongs to the family Pedaliaceae. *Sesamum indicum* is used as external poultice, emenagogue, diuretic, tonic and demulcent (Evans, 1996). Sesame seeds, which are used in traditional Indian (Ayurvedic) and Chinese medicine, contain 57% highly stable oil (Reshma *et al.*, 2010). Due to its high oxidative stability, sesame oil is added to margarines, salads, and frying oils (Yen and Lai, 1989). Sesame oil has advantages over other vegetable oils owing to its high nutritional and therapeutic value. Sesame oil was also used as a topical antibacterial, antifungal and antiviral agent by the traditional medical practitioners. The oil consists of glycerides of oleic, linoleic, palmitic, stearic and myristic acids and also contains a crystalline substance, sesamin, sesaminol, sesamolin, and a phenolic substance sesamol (Wallis, 1997). Sesamol is formed from decomposition of sesamolin (present in sesame oil with sesamin) during the processing of sesame oil. Sesamol has been reported to act as a metabolic regulator and to possess antioxidant (Vennila and Pugalendi, 2010), anti-aging (Sharma and Kaur,

2006), antimutagenic (Kaur and, Saini, 2000) antihepatotoxic (Ohta et al., 1994), chemopreventive (Kapadia et al., 2002) and anticarcinogenic activity and inhibits atherosclerosis (Decker, 1995). Sesamin and sesaminol are the major phenolic constituents of sesame oil which have been reported to possess a broad spectrum of pharmacological effects including anti-mutagenic, antioxidant, antihypertensive, anti-inflammatory antithrombotic and cardio protective effects (Saleem *et al*., 2014).

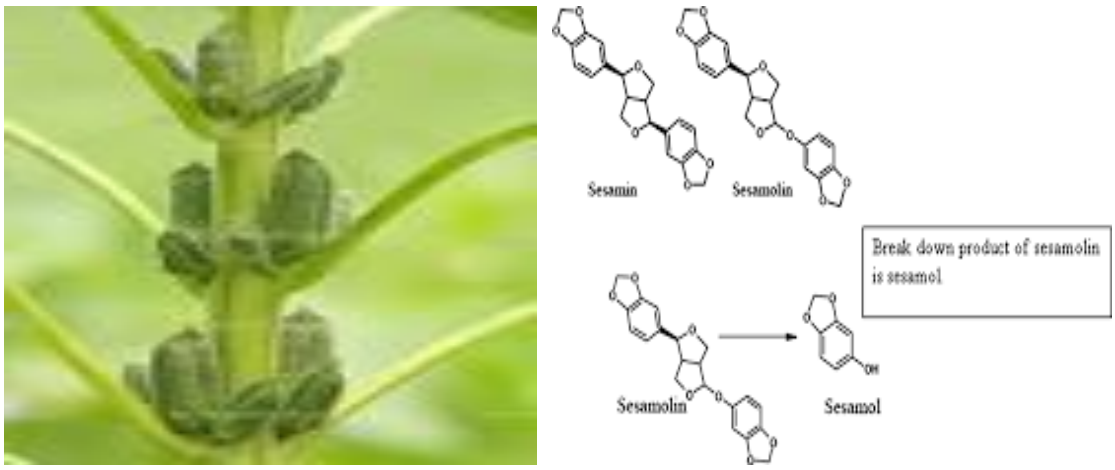

Figure. 1: Chemical Structure of Sesame (Lignans. Source: Bhatnagar *et al.*, 2013).

Sesame oil and Hypertension

Hypertension is one of the leading risk factors for heart disease and stroke. Hypertension is the medical term for high BP. BP is the pressure which arises in the blood vessels when blood is pushed out by the heart to all of the organs and body parts. BP is at its highest when the heart is contracting, and this is called systolic blood pressure. When the heart relaxes and rest between contractions BP decreases to its lowest level, called diastolic BP. Normal systolic blood pressure is around 110 -130 mm Hg. A normal value for diastolic pressure is around 80 mm Hg. Blood pressure over 140/90 mm Hg is characterised as high BP. The relationship between BP and risk of CVD events is continuous, consistent and independent of other risk factors. Hypertension increases the risk for a variety of CVDs (Rapsomaniki *et al.,* 2014), including stroke, coronary artery disease, heart failure, atrial fibrillation (Angeli *et al*., 2014). Drug therapy alone may not be sufficient enough to treat either the hypertension or atherosclerosis without the involvement of any dietary management. Dietary intervention thus becomes an integral part in course of the cardiovascular disease therapy.

In recent days foods enriched with natural antioxidants or polyunsaturated fatty acids are gaining the importance (Engelhard *et al.,* 2006). Sesame oil contains significantly more

polyunsaturated fats, which include omega-3 fatty acids. These beneficial fats help to protect the heart from damage and regulate BP. Sesame oil, in comparison to other dietary oils such as groundnut and sunflower, offers better protection against increased BP by the antioxidants (Sankar *et al.*, 2005).Several beneficial effects of the sesame oil were already recorded in ancient Indian medical literature, Ayurveda. (Sankar *et al.*, 2006) have reported that the sesame oil 35 g / day / person would reduce the BP. It has been conjectured that the beneficial role of sesame oil is due to the presence of several of its natural components sesamin, vitamin E or oleic acid.

Sesame oil on oxidative stress and antioxidants

Oxidative stress has a major role in development of CVDs. Oxidative stress represents an imbalance between ROS production and the cellular antioxidant defence system. ROS are a family of highly reactive species that causing cell damage either directly or through behaving as intermediates in diverse cell signaling pathways. The production of ROS and lipid peroxidation plays a significant role in the progression of CVDs. Free radicals react with lipids and causes peroxidative changes that result in enhanced lipid peroxidation (Girotti., 1985), which can be detected by the presence of peroxidation products (Young *et al.*, 1995), and results in alteration of antioxidant defense systems and lipid profile.

An antioxidant has been defined as antioxidant is defined as any substance that prevents or repairs the process of oxidation (Bachem *et al.*, 1999). Antioxidant defences can be divided into enzymatic and nonenzymatic. Enzymatic antioxidant defenses mainly include superoxide dismutase (SOD), glutathione peroxidase (GPx), catalase (CAT), and glutathione reductase (GR), among others. SOD enzymes generate H_2O_2, they work in collaboration with H_2O_2-removing enzymes. CAT, an exclusively peroxisomal enzyme in most tissues, converts H_2O_2 to water and O_2. However, the most important H_2O_2-removing enzymes are the GPx enzymes. GPx enzymes remove H_2O_2 by using it to oxidize reduced glutathione (GSH) to oxidized glutathione (GSSG). Glutathione reductase, a flavoprotein enzyme, regenerates GSH from GSSG, with NADPH as a source of reducing power (Ursini *et al.*, 1995). Nonenzymatic antioxidant defences include a variety of biological molecules, such as ascorbic acid (vitamin C), α-tocopherol (vitamin E), GSH, coenzyme Q, cysteine, carotenoids, flavonoids, polyphenols, and other various exogenous antioxidants (Venardos, 2007; Rodrigo *et al.*, 2013).

There are many mechanisms through which antioxidants may act such as scavenging reactive oxygen species or their precursors, inhibiting the formation of ROS, attenuating the catalysis of ROS generation via binding to metal ions, enhancing endogenous antioxidant generation, and reducing apoptotic cell death by upregulating the antiapoptotic gene Bcl-2 (Venardos *et al.*, 2007).

Sesame oil has long been regarded as a daily nutritional supplement for increasing cell resistance to lipid peroxidation (LPO) (Kaur **and** Saini, 2000). Sesame oil decreases LPO by inhibiting the generation of reactive oxygen free radicals. In addition to decrease lipid peroxidation and generation of reactive oxidative species, sesame oil increased the activities of antioxidative enzymes such as GPx, SOD, and catalase in rodents under various conditions of oxidative stress (Hemalatha *et al.*, 2004; Hsu *et al*., 2006; Hsu *et al*., 2004). A GSH-associated nonenzymatic defense mechanism may be involved in the effect of sesame oil on lipid peroxidation because sesame oil significantly decreases lipid peroxidation by inhibiting the generation of superoxide anion, which may be regulated by the circulating antioxidant system. (Philip *et al.*, 2010) and Mohamed (Saleem *et al.*, 2014) have reported that sesamin significantly decreased the TBARS and enhanced the levels of GSH, SOD and CAT is indicating the protective role of Sesamin. Sesamin is most powerful antioxidant lignan obtained from sesame oil.

Table 1. Antioxidant effect of sesame oil and its lignans.

S. No	Antioxidants	References
1.	Sesame oil	Esmaeilzadeh Kenari *et al.*, 2014
2.	Sesamin	Wenhui Si *et al*., 2013
3.	Sesamolin	Hou *et al.*, 2003
4.	Sesaminol	Cao *et al.*, 2013
5.	Sesamol	Vennila and Pugalendi, 2010

Sesame oil and Hyperlipidaemia

Lipids play an important role in CVDs, not only by the way of hyperlipidaemia but also by modifying the composition, structure and stability of cellular membranes. The liver is the major site for the synthesis and metabolism of cholesterol, bile acids and phospholipids. Phospholipids are essential components for the integrity of cellular membrane and subcellular organelles. Different mechanisms account for lipid accumulation; free fatty acids from adipose tissue or ingested food are normally transported into hepatocytes. The free fatty acids liberated from adipose tissue also enter into the myocardium, and the process is proportional

to the free fatty acid concentration in the coronary sinus. The heart can utilize free fatty acids for its energy requirements and the excess free fatty acid may be used for the synthesis of triglycerides, resulting in hypertriglyceridemia. Accumulation of triglycerides is also one of the risk factors in Coronary Heart Disease (CHD). The type of fat that is consumed can have either positive or negative effects on risk of CVDs. Saturated fatty acids (SFA) and *trans* fatty acids are generally considered unhealthy; whereas, monounsaturated fatty acids MUFA) and polyunsaturated fatty acids (PUFA) are considered beneficial (McGrane *et al*., 2011).

Cholesterol is carried through blood by particles called lipoproteins: LDL-C and HDL-C. Hypercholesterolemia, hypertriglyceridemia, high concentration LDL-C, VLDL-C, and low concentration of HDL-C are accepted as independent risk factors for atherosclerotic CVDs and mortality (Gotto & Brinton, 2004; Smith *et al.,* 2007). HDL-C reduces the risk of CVDs as it carries cholesterol away from the blood stream. Increase in serum HDL-C and decrease in serum LDL-C are important for lowering the risk of cardiovascular attack (Upadhyay, 2015).

Sesame oil supplementation led to the significant decrease in plasma TC, LDL-C, and TG levels and significant increase in plasma HDL-C. Sesame seed supplementation also decreased serum TC, LDL-C and lipid peroxidation, and increased antioxidant status in hyperlipidemic patients. Sesamin is one of the most important lignan components of sesame seeds. This phytochemical has been reported to exert hypocholesterolemic effects through inhibition of the intestinal absorption of cholesterol, increase of biliary cholesterol excretion, and downregulation of 3-hydroxy-3-methylglutaryl coenzyme A reductase activity (Hirose, 1991). The higher antihyperlipidemic activity of sesame oil and sesame seed is most likely due to the higher frequencies of the aforementioned phytonutrients, due to their lipophilic characteristics (Asgary *et al.,* 2013). Different lignan derivatives of sesame such as sesamin, sesamol, sesaminol, sesaminolinol, and pinoresinol possess antioxidant functions and can prevent against membrane lipid peroxidation (Penalvo *et al.,* 2006). Sesamol has been generally regarded as the main antioxidative component in sesame oil and is reported to have antihyperlipidemic activity (Vennila and Pugalendi, 2012). Furthermore, vitamin E and flavonoids that naturally occur in sesame have been reported to possess antioxidant and lipid-lowering properties (Ide *et al.,* 2003, Visavadiya and Narasimhacharya, 2008).

Sesame oil and an inflammation

The inflammatory response is a defense mechanism that evolved in higher organisms to protect them from infection and injury. This is important to localize and eliminate the

injurious agent and to remove the damaged tissue components, so that the body can begin to heal. Prolonged inflammations are often associated with severe detrimental side effects on health (Afsar Amhed, 2011). Alterations in inflammatory responses due to persistent inducers or genetic variations are on the rise over the last couple of decades, causing a variety of inflammatory diseases and pathophysiological conditions. Inflamation is widely considered to be an important contributing factor of the pathophysiology of CHD, particularly significant in the atherosclerotic process (Libby *et al*, 2009). Atherosclerosis, a major form of CVDs, has now been recognized as a chronic inflammatory disease. Sesame oil-enriched diet is an effective non pharmacological treatment for atherosclerosis by controlling inflammation and regulating lipid metabolism (Chandrakala *et al.,* 2015). Sesamin and Sesamol are the vital active constituents of sesame oil and represent a promising target for the treatment of pain and inflammation (Monteiro *et al.,* 2014). Sesamol is reported to decrease the inflammatory response and attenuates the associated organ damage in septic rats (Hsu *et al.*, 2006; Chu *et al.*, 2010). Sesamol downregulates the expressions of pro-inflammatory markers TNF-α, IL-1β, and nitric oxide and inducible nitric oxide synthase (iNOS) and because of this anti-inflammatory effect, multiple organs injury and mortality can be decreased.Sesamol also affects the macrophages to downregulate pro-inflammatory mediators production (Chu *et al.*, 2009). Sesame oil as dietary supplement produced significant anti-inflammatory activity and inclusion of sesame oil in diet maybe useful for an alternative choice for various inflammatory diseases (Mohamed Saleeme *et al.,* 2011).

CONCLUSION

In this review, the cardioprotective activities of sesame oil have been concisely reported. Sesame oil offers better protection against increased blood pressure, hyperlipidemia, lipid peroxidation and an inflammation by increasing the antioxidants and this might be due to the presence of its major lignans sesamin, sesamol and sesamolin. The lignans present in sesame oil are thought to be responsible for many of its unique chemical and physiological properties.

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