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Natural Antioxidants, Lipid Profile, Lipid Peroxidation, Antioxidant Enzymes of Different Vegetable Oils

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Abstract: Antioxidant plays a very important role in the body defense system against Reactive Oxygen Species (ROS). The free radicals also play an important role in combustion, atmospheric chemistry, biochemistry and biotechnology including human physiology. Fats and oils are energy sources that are composed mostly of triacylglycerols. Lipid ptofile are risk indicators of coronary heart disease. Various types of lipoproteins exist, but the two most abundant are Low-density Lipoprotein (LDL) and High-density Lipoprotein (HDL). Lipid peroxidation is the introduction of a functional group containing two catenated oxygyen atomsinto unsturated fatty acids in a free radical reaction. Life in oxygen has led to the evolution of biochemical adaptations that exploit the reactivity of Active Oxygen Species (AOS). Antioxidant enzymes are an important protective mechanism ROS. This paper highlight the functions of antioxidants in the blood and selected organs associated with health.

Key words: Antioxidant enzymes, Beta carotene, free radical, lipid profile, vegetable oils, vitamin E

INTRODUCTION

An important field of research today is the control of ‘redox’ status with the properties of food and food components. However, natural antioxidants present in the diet increase the resistance toward oxidative damages and they may have a substantial impact on human health (Boskou, 2006). The concepts of antioxidants, free radicals, and singlet O_2 species are terms that have been topics of research for decades (Azizan, 2006). Antioxidant compounds play an important role in our body due to favorable effects on human health. Consumption of food containing phytochemical with potential antioxidant properties can reduce the risk of human disease (Temple, 2000). Vegetable oils contain natural antioxidants. Chain breaking antioxidants are highly reactive with free radicals and form stable compounds that do not contribute to the oxidation chain reaction (El Diwani *et al*., 2009). Therefore, recent study highlights the functions of antioxidants in the blood and selected organs associated with health.

FREE RADICALS

Free radicals are also known as Reactive Oxygen Species (ROS) and these compounds are formed when oxygen molecules combine with other molecules. An oxygen molecule with paired electrons is stable; however oxygen with an unpaired electron is reactive (Daniel *et al*., 2005). The radicals are likely to take part in chemical reactions, taking electrons from vital components and leaving them damaged. Radicals also play an important role in combustion, atmospheric chemistry, polymerization, biochemistry, and many other chemical processes, including human physiology (Daniel *et al*., 2005). Reactive oxygen species can be classified into oxygen-centered radicals and oxygen-centered nonradicals. Oxygen-centered radicals are superoxide anion ($\cdot O_2^-$), hydroxyl radical ($\cdot OH$), alkoxyl radical ($RO\cdot$), and peroxyl radical ($ROO\cdot$). Oxygen-centered nonradicals are hydrogen peroxide (H_2O_2) and singlet oxygen ($^1O_2$) (Lee *et al*., 2004; Ki-Wan and You-Jin, 2006; Michalak, 2006).

Free radicals damage: Free radicals steal electrons from cells, DNA, enzymes and cell membranes. Removing these electrons changes the composition of the structure it was stolen from. Cells are damaged and therefore do not function normally. Enzymes cannot do their jobs as catalysts for cellular reactions. Compromising the integrity of cellular membranes leaves them vulnerable to attack by viruses, bacteria and other invaders. Oxygen free-radicals as the name implies, contain oxygen, and are highly reactive chemical species with the potential to react

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with almost every type of molecule in living cells. The highly reactive hydroxyl radical is especially toxic because it can react with proteins, polysaccharides, nucleic acids, and polyunsaturated fatty acids and cause alteration of their structure and functions (Natural Holistic Health Report, 2010; Daniel *et al.,* 2005).

ANTIOXIDANTS

Antioxidants are believed to play a very important role in the body defense system against ROS (Boxin *et al*., 2002; Vivek and Surendra, 2006). Antioxidant is a chemical that delays the start or slows the rate of lipid oxidation reaction. It inhibits the formation of free radical and hence contributes to the stabilization of the lipid sample. Natural antioxidants are constituents of many fruits and vegetables and they have attracted a great deal of public and scientific attention (El Diwani *et al*., 2009). Boskou, (2006) reported that the dietary antioxidants such as ascorbates, tocopherols and carotenoids are well known and there is a surplus of publications related to their role in health. Naturally, there is a dynamic balance between the amount of free-radicals generated in the body and antioxidants to quench and/or scavenge them and protect the body against their deleterious effects.

However, the amounts of these protective antioxidant principles present under the normal physiological conditions are sufficient only to cope with the physiological rate of free-radical generation (Ashok and Sushil, 2005). Vegetable oils contain natural antioxidants and the most common are tocopherols, which are hindered phenolic chain breaking antioxidants. Chain breaking antioxidants are highly reactive with free radicals and form stable compounds that do not contribute to the oxidation chain reaction (El Diwani *et al*., 2009).

The need for antioxidants defence: Most biologically-relevant free radicals are derived from oxygen and nitrogen and the so-celled ROS and Reactive Nitrogen Species (RNS). Both these elements are essential but in certain circumstances are converted into free radicals which are highly unstable and their reactive capacity makes them capable of damaging biologically relevant molecules such as proteins, lipid or carbohydrates (Peter, 2007). Antioxidants are molecules that retard or prevent the oxidation of other compounds. Not only soluble antioxidants but also complex enzymatic systems such as catalase, superoxide dismutase and some peroxidases may be used by cells to avoid undesired oxidations (Angelo, 2009). Sarvajeet and Narendra, (2010) reported that the ROS affect many cellular functions by damaging nucleic acids, oxidizing proteins, and causing lipid peroxidation and it is important to note that whether ROS will act as damaging, protective or signaling factors depends on the delicate equilibrium between ROS production and scavenging at the proper site and time. . Oxidative stress occurs when this critical balance is disrupted due to depletion of antioxidants or excess accumulation of ROS, or both (Scandalios, 2005).

Function of antioxidant: The most important and well-characterised natural antioxidants in the animal body are vitamin E and C. In fact in the body, all antioxidants are working in concert as a team, the (antioxidant system), responsible for prevention of the damaging effects of free radicals and toxic products of their metabolism. However, the antioxidant (team) acts to control levels of free radical formation as a coordinated system where deficiencies in one component impact the efficiency of others (Peter, 2007). Four possible mechanisms have been suggested (John, 1989) by which antioxidants function to reduce the rate of oxidation of fats and oils. These are:

- Hydrogen donation by the antioxidant.
- Electron donation by the antioxidant.
- Addition of the lipid to the antioxidant.
- Formation of a complex between the lipid and antioxidant.

However, it is thought that the first two mechanisms are the most probable modes of action of antioxidants.-CaroteneThe most important carotenoids are alphacarotene, beta-carotene, and beta-cryptoxanthin, lutein, violaxanthin, neoxanthin, and lycopene. Beta-carotene is the most widely studied carotenoid (Alam and Sultan, 2004). Carotenoids are widely distributed natural pigments responsible for the yellow, orange, and red colors of fruits, roots, flowers, fish, invertebrates, and birds (Delia, 1997). α, β-Carotene and lycopenes are the major carotenoids which are mainly composed of carbon and hydrogen atoms. In humans and animals carotenoids play an important role in protection against photooxidative processes by acting as oxygen and peroxyl radical scavengers (Jacques *et al*., 2008). β-Carotene is a fat soluble member of the carotenoids which are considered provitamins because they can be converted to active vitamin A. Betacarotene is converted to retinol, which is essential for vision. It is a strong antioxidant and is the best quencher of singlet oxygen (Lien *et al*., 2008). The best dietary sources of beta-carotene are yellow and orange fruits and vegetables. Some of them contain more than 80% of their provitamin A in the form of β-acarotene. Only some carotenoids found in nature have provitamin A activity.

Vitamin E (tocopherols and tocotrienols): Vitamin E is one of the most important lipid-soluble primary defense antioxidants (Handan *et al*., 2007; Paul and Sumit, 2002;

Abdalla, 2009). It is a generic term used for several naturally occurring tocopherols and tocotrienols. In its function as a chain-breaking antioxidant, vitamin E rapidly transfers its phenolic H-atom to a lipid peroxyl radical, converting it into a lipid hydroperoxide and a vitamin E radical (Bashir *et al*., 2004).

Palm vitamin E (30% tocopherols, 70% tocotrienols) has been extensively researched for its nutritional and health properties. The tocotrienols have been reported to be natural inhibitors of cholesterol synthesis (Aboua *et al*., 2009). Tocopherols (vitamin E) and tocotrienols (provitamin E) are powerful antioxidants that confer oxidative stability to red palm olein (RPO) as well as help to keep the carotenoids and other quality parameters of the oil stable (Nesma *et al*., 2010). Vitamin E scavenges peroxyl radical intermediates in lipid peroxidation and responsible for protecting Poly Unsaturated Fatty Acid (PUFA) present in cell membrane and density lipoprotein (LDL), against lipid peroxidation (Vivek and Surendra, 2006). Tocopherols, a lipid soluble antioxidant are considered as potential scavengers of ROS and lipid radicals. Tocopherols are considered as a major antioxidant in biomembranes, where they play both antioxidant and non-antioxidant functions. Tocopherols are considered general antioxidants for protection of membrane stability, including quenching or scavenging ROS. Out of four isomers of tocopherols (α-, β-, γ-, δ-) found in plants, a-tocopherol has the highest antioxidative activity due to the presence of three methyl groups in its molecular structure (Sarvajeet and Narendra, 2010).

FATTY ACIDS

Oils are important nutrients and energy sources that are composed mostly of triacylglycerols. Dietary triacylglycerols are composed of fatty acids that may vary in their chain length, degree of unsaturation, isomeric orientation of double bonds and position within the triacylglycerol molecule (Edem, 2003; Susanna *et al*., 2004). Dietary oils and fats are composed of different types of fatty acids (FA). Fatty acids are saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) (Amr *et al*., 2010).

VEGETABLE OILS

Approximately 75% of the world's production of oils and fats come from plant sources (Okpuzor *et al*., 2009).Vegetable oils and fats are principally used for human consumption but are also used in animal feed, for medicinal purposes, and for certain technical applications (Poonam, 2010). There is a great interest in finding antioxidants from natural sources for food. Lipids containing polyunsaturated fatty acids are readily oxidized by molecular oxygen and such oxidation proceeds by a free radical chain mechanism (Heidar *et al*., 2010). The most common are tocopherols, which are hindered phenolic chain breaking antioxidants. Chain breaking antioxidants are highly reactive with free radicals and form stable compounds that do not contribute to the oxidation chain reaction (Carandang, 2008).

Palm oil: Palm oil is a lipid extracted from the fleshy orange-red mesocarp of the fruits of the oil palm tree (*Elaeis guineensis*) which contain 45 to 55% oil. Palm oil is light yellow to orange-red in color depending on the amount of carotenoids present. Palm oil may be fractionated into two major fractions: a liquid oil (65-70%) palm olein and a solid fraction (30-35%) stearin (Edem, 2002). Palm oil is the second major edible oil used worldwide. Palm olein (PO), a liquid fraction obtained from the refining of palm oil, is rich in oleic acid (42.7-43.9%), beta-carotene and vitamin E (tocopherols and tocotrienols). Although palm oil and palm olein are produced from the same plant and share many similar properties, the main difference between them is their chemical state at room temperature. Semi-solid palm oil is used more frequently as a fat in bakery products, whereas liquid palm olein is considered the "gold standard" and is the most widely used oil for frying in the world (Arlene, 2010).

Palm olein is the preferred oil for cooking and frying because it has good oxidative stability. However, it tends to crystallize and becomes cloudy in cold weather in temperate countries (Nor-Aini *et al*., 2003). According to the American Heart Association the monounsaturated fats have been found to be better for heart health than saturated fats. It has virtually no trans fats, which are made by adding hydrogen to many polyunsaturated oils to make them semisolid. Trans fats have negative impacts on heart health. Palm olein can be made more solid by adding palm stearin, the other fraction of palm oil (Lexa, 2010).

One of the unique characteristics of palm oil is its high content of carotenoids and tocopherols. Carotenoids, together with tocopherols, contribute to the stability and nutritional value of palm oil. It is oxidatively stable due to a fatty acid composition with low polyunsaturation and high antioxidant content. While most vegetable oils provide mainly α- or γ-tocopherol, palm oil is unique since it contains relatively high concentrations of homologue tocotrienols (α, γ, and δ). Moreover, palm oil is one of the richest sources of α- and β-carotene (400-3500 mg/kg), which constitute more than 80% of the total carotenoids in palm oil (Ming *et al*., 2009). Palm oil is semi-solid at room temperature; a characteristic brought about by its 50% saturation level.

Red Palm Oil (RPO): Red palm oil is extracted from the oil palm (*Elaeis guineenis*) fruit (Monica *et al*., 2006; Edem and Akpanabiatu 2006). It derives its red colour from the high content of α- and β-carotenes, which can make up 0.08% (w/w) of the crude oil (Monica *et al*., 2006). Red palm oil is the oil obtained before refining and the characteristic colour of RPO is due to the abundance of carotenoids (500-700 mg /L) in the crude oil (Edem, 2009). Red palm oil is unique as compared to other dietary fats in that palm oil contains the highest known concentrations of natural antioxidants, particularly provitamins A carotenes and vitamin E (Paul and Sumit, 2002).

Red palm oil contains high levels of carotene but its intense red color makes it unacceptable for many applications (Jack and Peter, 1998). Several studies have illustrated that RPO is a rich cocktail of lipid-soluble antioxidants such as carotenoids (α- and β-carotene, lycopenes), vitamin E (in the form of α-, β-, δ-tocotrienols and tocopherol) and ubiquinone (mostly Coenzyme Q10) (Jacques *et al*., 2008; Edem, 2002). Feeding experiments using various animal models have highlighted that red palm oil is beneficial to health by reducing oxidative stress (Oguntibeju *et al*., 2010). Many studies have demonstrated the protective effects of red palm oil in an ischemia model of oxidative stress and modulation of the serum lipid profile in rats (Bester *et al*., 2010; Oguntibeju *et al*., 2010). Red palm oil is the only vegetable oil with a balanced composition of saturated and unsaturated fatty acids both in processed and unprocessed forms and it contains carotenoids, phosphatides, sterols, tocopherols and trace metals (Aboua *et al*., 2009).

Red palm oil is healthy because it contains carotenoids and a special form of vitamin E. Most people are not aware of the fact that many different kinds of vitamin E occur in nature and that some forms of vitamin E are more beneficial than others. Red palm oil contains vitamin E tocotrienols, which acts as a super-antioxidant and the carotenoids in red palm oil also act as antioxidants (Azizan, 2006).

Corn oil: Corn oil presents a relatively high concentration of polyunsaturated fatty acids (PUFA).Due to the high levels of unsaturation, these lipids are highly susceptible to free radical oxidative reactions, giving rise to the formation of lipid peroxides. Many investigations suggest that a large number of polyunsaturated fatty acids produces more lipid peroxides and may have mutagenic activity (Valls *et al*., 2003). Corn oil is the most unsaturated oil among widely consumed oil. It is rich in oleic, linoleic and linolenic acids. Therefore, it is easily affected by free radical reactions, which results in the formation of oxidized LDL. This particle showed another significant risk factor for atherosclerosis (Recep *et al*., 2000). Omega-6 and omega-3 fats are polyunsaturated fatty acids that are precursors to a very important class of signaling molecules called eicosanoids, which have a hand in virtually every bodily process. Omega-6 and omega-3 fats compete with one another for the enzymes that convert them into eicosanoid precursors. Omega-6-derived eicosanoids and omega-3-derived eicosanoids have different functions. Therefore, the balance of omega-6 to omega-3 fats in the diet influences the function of the body on virtually every level. Omega-6 eicosanoids tend to be more inflammatory, although the eicosanoid system is extraordinarily complex and poorly understood.Coconut oil Coconut oil is a colorless to pale, brownish yellow oil (Cecille *et al.*, 2010). It is the major sources of saturated fat apart from palm kernel. They are the only natural sources of lauric oil available to the world market. Coconut oil is the principal cholesterol-raising fat because it contains large amounts of lauric (C: 12: O) and myristic (C: 14: 0) acids. Coconut oil consists of more than 90% of saturated fats with traces of few unsaturated fatty acids. Coconut oil as saturated oil is mostly small and medium chain triglycerides. The amount of tocopherols in coconut oil is low as compared to other vegetable oils (Organic facts, 2010).

Raymond (2011) reported that coconut oil is unusually rich in short and medium chain fatty acids. Shorter chain length allows fatty acids to be metabolized without use of the carnitine transport system. Coconut oil is composed predominantly of medium chain fatty acids that do not participate in the biosynthesis and transport of cholesterol. The medicinal effects of coconut oil are also due to its medium-chain fatty acids. Lauric acid, the major fatty acid from the fat of the coconut (Cecille *et al*., 2010).

LIPID PROFILE

A standard lipid profile consist of total cholesterol (TC), HDL-C, triglycerides (TGs). The laboratory also generally reports a value for LDL-C that may have been calculated by the Friedewald formula (Vera, 2007).

$$\text{LDL (mg/dL)} = \text{Total Cholesterol} - \text{HDL Cholesterol} - \text{Triglycerides}/5$$

Lipid profiles are risk indicators of coronary heart disease (Edem, 2002). Cholesterol is water-insoluble and is transported inside lipoproteins. Various types of lipoproteins exist, but the two most abundant Are Low-density Lipoprotein (LDL) and High-density Lipoprotein (HDL) (Anthony, 2005). The relationship between cholesterol and saturated fat with coronary artery disease is identified as early as in 1950 (Limbu *et al*., 2008). Strong correlations have been shown between increased

Table 1: Cholesterol and triglyceride guidelines

Total Cholesterol Level	Total Cholesterol Category
<200 mg/dL	Desirable
200-239 mg/dL	Borderline high
≥240 mg/dL	High blood cholesterol. A person with this level has more than twice the risk of heart disease as someone whose cholesterol is below 200 mg/dl.
LDL Cholesterol level	LDL Cholesterol Category
<100 mg/dL	Optimal
100-129 mg/dL	Near optimal
130-1159 mg/dL	Borderline high
160-189 mg/dL	High
≥190 mg/dL	Very high
HDL Cholesterol	LevelHDL Cholesterol Category
<40 mg/dL	A major risk factor for heart disease
40-59 mg/dL	The higher HDL level, the better.
≥60 mg/dL and above	Considered protective against heart disease
Triglyceride Level	Triglyceride Category
<150 mg/dL	Optimal
150-199 mg/dL	Borderline high
≥200 mg/dL	High

*LDL indicates low-density lipoprotein; HDL, high-density lipoprotein

plasma total cholesterol, low density lipoprotein cholesterol and increased incidence of coronary heart disease (Kate, 2010). Table 1 showed the cholesterol level in relation to heart risk factor.

Total cholesterol (TC)

Cholesterol is found in virtually all animal cells and is primarily a membrane component as well as one of the building blocks of stress and sex hormones, and bile acids (Maduka *et al*., 2009). Cholesterol is needed in the body to insulate nerves, make cell membranes and produce certain hormones, and it is an important lipid in some membranes.

Cholesterol plays a major role in human heart health. Cholesterol can be both good and Bad. High-density Lipoprotein (HDL) is good cholesterol and Low-density Lipoprotein (LDL) is bad cholesterol. The HDL in serum is a leading risk factor for human cardiovascular disease such as coronary heart disease. Excess cholesterol in the bloodstream can form plaque (a thick, hard deposit) in artery walls (Hongbao, 2004).

Triglyceride (TG): Triglyceride is the most common type of fat in the body. People with heart disease diabetes have high triglyceride levels. Normal triglyceride levels vary with age and sex. A high triglyceride level combined with low HDL cholesterol or high LDL cholesterol seems to speed up atherosclerosis, which is the buildup of fatty deposits in artery walls that increase the risk for heart attack and stroke (Hongbao, 2004).

The UPMC (2008) reported that the triglycerides are a form of stored fat and this is the most common fat found in foods and in the body. Fats and oils in foods are mainly in the form of triglycerides which are carried in the blood. High-Density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C): Cholesterol cannot dissolve in the blood. It has to be transported to and from the cells by carriers called lipoproteins. These two types of lipids along with triglycerides make up the total cholesterol count which can be determined through a blood test. When too much LDL cholesterol circulates in the blood it can slowly build up in the inner walls of the arteries that feed the heart and brain. Together with other substances it can form plaque a thick hard deposit that can narrow the arteries and make them less flexible. This condition is known as atherosclerosis (American Heart Association, 2007). About one-fourth to one-third of blood cholesterol is carried by High-density Lipoprotein (HDL). Medical experts think that HDL tends to carry cholesterol away from the arteries and back to the liver, where it's passed from the body.

Lipid peroxidation: Lipid peroxidation is the introduction of a functional group containing two catenated oxygen atoms, O-O, into unsaturated fatty acids in a free radical reaction (Wang, 2005). Polyunsaturated fatty acids susceptible to free radical attack are initiated by the formation of a carbon-centered radical by the abstraction of a hydrogen atom at one of the double bonds of the lipid. Lipid peroxidation is also one of major causes of quality deterioration during the storage of fats, oils or other lipid-rich foods (Wang, 2005). Lipid peroxidation is the most extensively studied manifestation of oxygen activation in biology. It is broadly defined as "oxidative deterioration of PUFA" which are fatty acids that contain more than two carbon carbon double bonds (Maneesh and Jayalekshmi, 2006). Lipids when reacted with free radicals can undergo the highly damaging chain reaction of lipid peroxidation leading to both direct and indirect effects (Devasagayam *et al*., 2004).

Peroxidation of lipids is a binding process connected with the formation of aldehydes. Malondialdehyde (MDA) (Niedworok and Bielaszka, 2007). It is the end product of lipid peroxidation, is a good marker of free radical-mediated damage and oxidative stress (Atip *et al*., 2010). It has been utilized as a suitable biomarker for lipid peroxidation (Adriano *et al*., 2004). Malonaldehyde, can react with the free amino group of proteins, phospholipid, and nucleic acids leading to structural modification, which induce dysfunction of immune systems (Lee *et al*., 2004). Vitamin E supplementations lead to a significant decrease in MDA concentrations (Ashok and Sushil, 2005).

ANTIOXIDANT ENZYMES

Life in oxygen has led to the evolution of biochemical adaptations that exploit the reactivity of Active Oxygen Species (AOS). The term AOS is generic, embracing free radicals such as superoxide (O_2) and hydroxyl radicals H_2O_2 and singlet oxygen (Graham and

Christine, 1998). Antioxidant enzymes, including superoxide dismutase, catalase, and glutathione peroxidase/reductase, convert reactive oxygen species into nonreactive oxygen molecules (Lee *et al*., 2004). Antioxidant enzymes are an important protective mechanism the ROS and, their effectiveness vary with the stage of development and other physiological aspects of the organism. The most important antioxidant enzymes are superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX) (Jinghua *et al*., 2007).

Superoxide dismutase: Superoxide radical ($^{\cdot}O_2^{-}$) is generated as by-product in aerobic organisms from a number of physiological reactions and redox reactions in cell (Andrea *et al*., 1989). It can react with hydrogen peroxide (H_2O_2) to produce hydroxyl radical ($^{\cdot}OH^{-}$), one of the most reactive molecules in the living cells. Hydroxyl radical can cause the peroxidation of membrane lipids. To ameliorate the damage caused by hydroxyl radical formed superoxide radical and hydrogen peroxide, organisms have evolved mechanisms to control the concentration of the two reactants (Campana *et al*., 2004). Superoxide dismutase is a well-known antioxidative enzyme with can convert superoxide into hydrogen peroxide (Henry *et al*., 2006). Superoxide dismutase is an important enzyme family in living cells for maintaining normal physiological conditions and for coping with stress (Olawale *et al*., 2008). Superoxide dismutase spontaneously dismutates (O_2^{-}) anion to form O_2 and H_2O_2. Superoxide dismutase mainly acts by quenching of superoxide ($O^{-}{}_2$) (Vivek and Surendra, 2006).

Catalase (CAT): Catalases (EC 1.11.1.6) are the class of enzymes, which catalyse the decomposition of hydrogen peroxide to oxygen and water and these ubiquitous enzymes have been isolated and purified from different natural sources including animal tissues, plants and micro-organisms. All aerobic organisms evolved specific enzyme systems to neutralize potentially lethal effects of hydrogen peroxide (Malcolm *et al*., 1977; Noreddine *et al*., 2005). Catalase converts H_2O_2 to O_2 and H_2O (Tetyana *et al*., 2005).

CONCLUSION

Antioxidant plays a very important role in the body defense system against reactive oxygen species. Vegetable oils contain natural antioxidants. Lipid peroxidation is the introduction of a functional group containing two catenated oxygyen atomsinto unsturated fatty acids in a free radical reaction. Antioxidant enzymes are an important protective mechanism ROS. This study investigated the functions of antioxidants in the blood and selected organs associated with health.

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