

A Comparative Study of the Effect of Heating on Antioxidant Potential and Lipid Profile of Rats Fed with Two Vegetable Oils-sunflower Oil and Sesame Oil (Commonly Used in Culinary Preparation)

George Saramma^{1*} and Chaturvedi Padmaja²

¹Department of Biomedical Sciences, Faculty of Medicine, University of Botswana, Botswana.

²Department of Biological Sciences, Faculty of Sciences, University of Botswana, Botswana.

Authors' contributions

This work was jointly carried out in collaboration between the two authors. Author GS managed the analyses of the study, managed the literature searches and performed the statistical analysis while author CP designed the study wrote the protocol. Both the authors read and approved the final manuscript.

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(3) Anonymous, Federal University of Rio de Janeiro, Brazil.

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ABSTRACT

Aims: Vegetable oils are fats, which are extracted from plant materials especially from seeds, which may change its chemical composition when heated. Therefore the present study investigated the effect of heating of sunflower oil and sesame oil on the in-vivo antioxidant status and the lipid profile in Wistar albino rats.

Place and Duration of Study: Department of Biological Sciences, University of Botswana, Botswana. The study was conducted from January 2012 - December 2012.

Methodology: The animals were divided into five groups of six rats each and maintained as follows: Normal control received the normal diet and two positive controls treated with heated sunflower oil and sesame oil, two experimental groups-treated sunflower oil and sesame oil after

*Corresponding author: E-mail: Saramma.George@mopipi.ub.bw;

frying the potato chips. At the end of the experimental period of 60 days the rats were sacrificed and the blood was collected for biochemical estimations. The weights of the animals were recorded every week.

Results: The results indicated that sesame oil is much better in keeping the antioxidant status and cause lesser lipid peroxidation as well as hepatotoxicity when compared to sunflower oil. Again the cardioprotective effect of sesame oil is higher than that of the sunflower oil.

Conclusion: So in conclusion, sesame oil showed a higher level of protective effect than that of sunflower oil and is a better choice for culinary purposes.

Keywords: Polyunsaturated; lipid peroxidation; oxidative stress; hepatotoxicity; cardioprotective; omega 3 fatty acids.

1. INTRODUCTION

Cooking oil is plant, animal, or synthetic fat, which is edible. It is often used in frying, baking, seasoning and other types of cooking. Biochemically it is an edible triester of fatty acids and glycerol [1]. The appropriate amount of fat as a component of daily food consumption is a topic of controversy. The FDA recommends that 30% or fewer of calories consumed daily should come from fat. Other nutritionists recommend that not more than 10% of a person's daily calories should come from the fat [2]. Heating oil changes its characteristics. Oils that are healthy at room temperature can become unhealthy when heated above certain temperatures; this is due to the changes occurring in their chemical composition during the process of heating. When choosing cooking oil, it is important to match the oil's heat tolerance with the cooking methods used. The smoke point of any oil depends primarily on its free fatty acid content (FFA) and molecular weight. Through repeated use, as in deep frying, the oil accumulates food residues or by-products of the cooking process that lower its smoke point further [3]. During cooking, the oils and fats are exposed to high temperature which may result in changes in their chemical properties. Heating oil at a temperature above its smoke point results in breaking down its triglyceride to glycerol and fatty acids. Furthermore, heating breaks down the glycerol to acrolein which ends up in losing flavor and nutritional value of the specific oil. In addition, the heating of oils and fats without catalysts produces secondary lipid peroxidation products such as carbonyls and cyclic fatty acids which are toxic to human body [4]. Experts say that the consumption of dishes cooked in reheated oil may expose you to high levels of toxic aldehydes; chemicals that are known to cause neurodegenerative diseases and cancer. This finding does not exclude even popular cooking oils like soybean and sunflower oils that are also capable of generating these harmful

chemicals when reheated. Researches on heated oils indicate the possibility of these to undergo thermal oxidation which results in the production of reactive oxygen species (ROS) which are harmful to the cells. In response to ROS production, the body activates its antioxidant system to defend against invasion of free radicals, which results in oxidative stress [5].

Sesame oil is obtained from seeds of *Sesamum indicum*, a plant that grows natively in India. It is an annual plant growing 50 cm to 100 cm tall. It has oppositely arranged leaves which are 4 cm to 14 cm long with an entire margin [6]. The oil from the nutrient-rich seed is popular in alternative medicine, from traditional massages to the traditional Indian medical practice, Ayurveda. It has been used in the treatment of several chronic diseases, including hepatitis, diabetes and migraines. Research shows that sesame seed oil is a potent antioxidant [7]. It penetrates into the skin quickly and enters the blood stream through capillaries. Molecules of sesame seed oil maintain good cholesterol (HDL) and lower bad cholesterol (LDL). Sesame oil has a lowering effect on blood pressure and levels of sodium in the blood [8].

The sunflower, or *Helianthus annuus*, is a distinctive plant which produces large bright yellow flowers which resemble small suns, the flowers grow on tall stalks with simple leaves, and they have been known to reach the height of 3 m in ideal growing conditions. Sunflower oil is one of the most commonly and widely used cooking oil in the world [9]. It is a rich source of Vitamin E, A and D with low saturated fats and has the ability to withstand high temperatures. Nevertheless, it is not devoid of side effects and draw backs. In addition to vitamin E, the oil is also rich in Omega 6 fatty acid which is a causative agent of colon and prostate cancer. As the sunflower oil contains vitamin E, it can lead to

decreased clotting of blood and this can elevate the risk of bleeding [10].

Heating cooking oil or fats changes its chemical composition and reuse of such oils which are exposed to high temperatures can cause harmful effects. So the main objectives of this study were to analyze the biochemical changes in the blood biomarkers and to establish the toxic effect of two different cooking oils commonly used in culinary preparations when exposed to high temperature during cooking. Hence to summarize, the main goals were to evaluate the antioxidant status in the blood samples of albino rats after feeding them with used cooking oils and next to compare the extent to which each of these oils can produce the changes in the lipid profile of these rats fed with these cooking oils.

2. MATERIALS AND METHODS

2.1 Plant Material

Oils were purchased from the local supermarkets (Spar and Pick 'n' Pay in South Africa)

2.2 Chemical

All the chemicals used were of the analytical grade and bought from Sigma-Aldrich Chemical Co. (St. Louis, MO, USA).

2.3 Animals

Male albino Wistar rats weighing approximately 200–250 g were used for all the experiments. They were housed in colony cages at an ambient temperature of 25-28°C with a 12-hour cycle of light and dark. Animals had water *ad libitum* and were fed on commercial normal diet for rats bought from Nola Food Corp. (Cape Town, South Africa). The experiments were conducted following internationally accepted principles for laboratory animal care at the Department of Biology, University of Botswana, Botswana.

2.4 Oil Samples Preparation

The oils were heated or fried separately; there were two groups of rats for each of the oil. One group received heated oil and the other one received fried oil. The oils were prepared in the following manner: cooking oil was heated for four minutes in the absence of any food items. After that the oil was allowed to cool and then it was mixed with normal rat food and administered to

the first group of rats used as positive control (PC) groups. The other groups of rats were fed with oils that were used to fry thin strips of potatoes for four minutes as well. The potatoes were discarded and the oils were mixed with normal rat food named as experimental groups (EX). Oils were mixed with feed at the rate of 10% of the feed weight.

2.5 Experimental Design

The animals were divided into five groups of six rats each and maintained as follows: Group 1- NC-Normal control- received commercial diet without any oil supplemented Group 2- PC 1-Positive control- treated with heated sunflower oil (10 mL/ Kg body weight) Group 3- PC 2- Positive control- treated with heated sesame oil (10 mL/ Kg body weight) Group 4- EX 1-Experimental group- treated with sunflower oil used to fry the potatoes (10 mL/ Kg body weight) Group 5- EX 2-Experimental group- treated with sesame oil used to fry the potatoes (10 mL/ Kg body weight)

The experiment was run for 60 days, at the end of the experiment the rats were fasted overnight and the rats were killed with mild ether anesthesia. Blood was collected in heparinized tubes and centrifuged at the rate of 6000 rotations per minute. Plasma samples were drawn after that and stored at -70°C for various biochemical estimations.

2.6 Biochemical Analysis

Thiobarbituric acid reactive substances (TBARS) in plasma were estimated by method described by Niehaus and Samuelsson [11] and reduced glutathione (GSH) was estimated by the method of Eilman [12]. Superoxide dismutase (SOD) was assayed by the method of Kakkar et al. [13]. The assay of SOD activity was based on the principle of inhibitory effects of SOD on reduction of nitro blue tetrazolium dye by superoxide radicals. A single unit of enzyme was expressed as 50% inhibition of NBT (Nitro blue tetrazolium) reduction /min/mg protein. Catalase (CAT) was estimated by the method of Hans Bisswagner [14]. Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Alkaline phosphatase (ALP), were estimated by using the kits from Sigma- Aldrich Chemical Company, (St. Louis, MO) USA. LDL, HDL Total cholesterol and triglycerides were estimated by using kits also from Sigma.

2.7 Statistical Analysis

All data were expressed as mean±S.E. mean with n=6. Analysis of variance was performed by one way ANOVA and significant difference between the means were determined by Holm-Sidak method. P -value ≤ 0.05 was regarded as statistically significant value. In all these cases, Statistical Software Sigma stat, 3.1 were used to analyze the data.

3. RESULTS

3.1 Percentage Increase in Weight

The average weights of these animals are shown in Figs. 1 and 2 which shows a gradual increase in weight from week one onwards, this may be due to lipids getting deposited in the adipose tissue. This was highest in PC 1 than in EX 1. There was no significant difference in weight gain in any of these groups.

3.2 Lipid Peroxidative Indices and Liver Markers

The results presented in Table 1 shows liver function indices of alanine aminotransferases (ALT), aminotransferases (AST), alkaline phosphatases (ALP), concentrations in the serum after 60 days of oral administration of sunflower oil and sesame oil. There was a significant ($P < 0.05$) increase in the activities of all these liver marker enzymes (ALT, AST and

ALP) in the EX groups when compared to control groups (NC). The PC groups did not show any significant difference in the liver marker enzymes when compared with the NC group. The levels of TBARS are a clear indication of the amount of lipid peroxidation in every group and it also showed the same type of effects as the liver markers.

3.3 The Antioxidant Status in the Blood

The antioxidant status in the blood included the non-enzymatic antioxidants such as GSH as well as the enzymatic antioxidants such as CAT and SOD (Table 2). The results indicate that all the parameters checked showed a significant decrease in Ex groups when compared to NC groups ($P \leq 0.05$). The PC groups did not show any significant difference between the NC groups but they showed a slight variation in different oils.

3.4 Lipid Profile in the Plasma

The results of the lipid profile in the blood plasma are presented in Table 3. It shows that the consumption of the oils had significantly lowered HDL levels ($p < 0.001$) in EX groups but the levels are different in sesame oil, it is much higher when compared to the sunflower oil. All other parameters checked showed significant increase in EX groups when compared to NC group, once more the levels are slightly different for both the oils used.

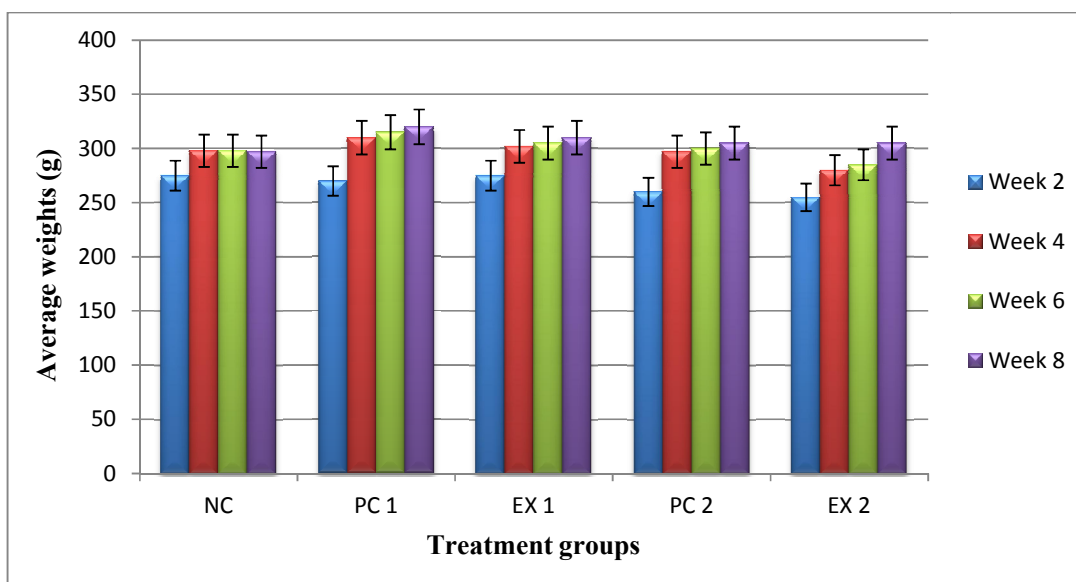


Fig. 1. Average weights of experimental rats taken at an interval of two weeks over a period of eight weeks

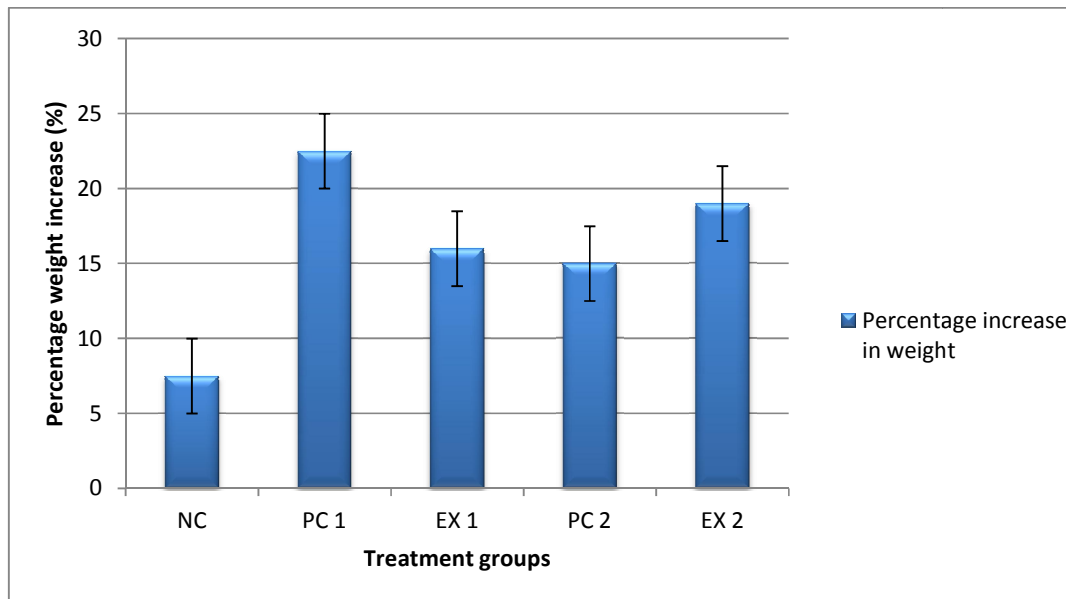


Fig. 2. % weight increase in weight of rats fed with different oils

Table 1. Lipid peroxidative indices

Groups	TBARS (nmol/L) plasma	AST (U/L) plasma	ALT (U/L) plasma	ALP (U/L) plasma
NC	1.28±0.08	40.16±0.23	38.98±0.09	45.76±0.04
PC1	1.58±0.21	46.95±0.56	39.04±0.46	47.96±0.34
PC2	1.05±0.34	38.05±0.91	34.08±0.05	42.76±0.72
EX1	6.87±0.18 *	78.95±0.41*	76.88±0.03*	88.56±0.17*
EX2	5.07±0.11 *	67.15±0.71*	71.67±0.23*	83.76±0.67*

* Significantly different; n= 6 in each group and the results were given as mean±SEM

TBARS: Thiobarbituric acid reactive substances, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase and ALP: Alkaline phosphatase

Table 2. The antioxidant levels in the blood

Groups	GSH (mg/dl) plasma	CAT (U/mg Hb) Haemolysate	SOD (U/mg Hb) Haemolysate
NC	35.07±1.09	48.75±1.32	2.65±1.17
PC1	34.13±0.12	44.15±1.01	2.15±0.19
PC2	38.67±1.11	49.78±0.92	2.81±0.13
EX1	17.88±0.34*	28.48±1.19*	1.28±0.48*
EX2	19.09±0.84*	32.46±0.61*	1.88±0.98*

* Significantly different; n= 6 in each group and the results were given as mean±SEM

GSH: Reduced glutathione, SOD: Superoxide dismutase and CAT: Catalase

4. DISCUSSION

Most of the lipids are in the form of triglycerides and they are the major fuel source in the body. Other lipids, including phospholipids, glycolipids and cholesterol are crucial constituents of the biological membrane. Fats are part of a normal, balanced, healthy diet and the body needs them for a variety of metabolic reactions. Fats provide

a concentrated source of energy. One gram of fat provides 37 kJ (9 kcal), more than double that provided by either protein or carbohydrate which provide 17 kJ/g (4 kcal) and 16 kJ/g (3.75 kcal), respectively [15]. Fat is a carrier for fat-soluble vitamins A, D, E and K. Some fats are essential to our well-being; these are known as the essential fatty acids (EFA's) often referred to as the omega fatty acids. Linoleic acid (omega 6)

and alpha linoleic acid (omega 3) are the most common essential fatty acids found in vegetable oils. Individual fatty acids can either be saturated or unsaturated and the latter being further subdivided into mono and polyunsaturated fatty acids. Fatty acids are either saturated or unsaturated. Saturated fats have no double bonds while the unsaturated fatty acids have single or multiple double bonds. Saturated fatty acids are extremely stable, that is, they do not easily become rancid, and they can increase blood cholesterol levels, one of the major factors in heart disease [16].

Figs. 1 and 2 showed the effect of these oils in the weight of these animals and result did not show any significant difference. The effects of sunflower oil and sesame oil on lipid peroxidation is presented in Table 1 which indicate an increase in lipid peroxidation as measured by formation of TBARS or dyne conjugates. This shows the mitochondrial dysfunction in rats subjected to the oxidative stress created by reused oils. This was much restricted in the control groups. The data obtained showed that the reused oils administration in the experimental groups in albino rats caused acute oxidative stress along with necrosis in the liver, which corresponded to the elevation of serum ALP, ALT and AST activity [17]. These pathological changes were accompanied with structural alterations of the hepatocytes, including glycogen and fat accumulation, organelle abnormality and cytoplasmic membrane degeneration due to lipid peroxidation causing the leakage of liver enzymes in to the blood stream. These conditions were not occurred in the control groups. Again the liver markers levels were

higher in sunflower oils treated when compared with sesame oil treated experimental groups [18]. The antioxidant status is given in Table 2 which shows that the positive control groups have almost the same antioxidant status as that of the normal control but the experimental groups were significantly different from the control groups. GSH is a non-enzymatic antioxidant which inhibits the generation of reactive oxygen species and hence the oxidative stress that damages the structural integrity of cell membrane and membrane organelles. The decrease in GSH levels in EX groups were due to the decreased availability of GSH caused by enhanced lipid peroxidation. In the present study, a significant decrease in the GSH content in the EX groups as compared to the entire PC and NC groups were also observed. A decrease in the SOD and Catalase activities were observed in EX 1 and EX 2 where reused oils were administered. It appears that the entire control group takes over the work of scavenging the free radicals and hence the normal levels of both enzymatic and non-enzymatic anti-oxidant were maintained. SOD catalyzes the dismutation of superoxide into oxygen and hydrogen peroxide, and it is an important antioxidant defense in all cells exposed to oxygen. Hydrogen peroxide is then converted to oxygen and water by glutathione peroxidase and CAT [19]. It has been reported that SOD, CAT, and GSH constitute a mutually supportive team of defense against reactive oxygen species. One of the secondary effects of ROS formation is mitochondrial dysfunction which results in ATP depletion and oxidative stress. The results prove that the sesame oil worked in the way of scavenging the superoxide anion thus preventing the chain reactions that leads to the production of ROS.

Table 3. Levels of different types of lipids in the plasma

Groups	Total cholestrol (mg/dL)	HDL (mg/dL)	LDL (mg/dL)	Triglycerides (mg/dL)
NC	10.20±1.25	56.09±1.32	15.00±2.23	61.00±4.21
PC1	18.28±1.09	47.08±1.52	36.08±1.92	111.00±0.28
PC2	12.02±0.28	68.07±0.39	16.68±1.62	66.00±1.53
EX1	124.40±9.10*	12.80±1.14*	150.87±3.1*	230.00±9.31*
EX2	42.45±1.18*	21.87±0.17*	105.07±1.1*	201.80±0.91*

n = 6 in each group

* Shows significant difference and the results were given as mean ±SEM. *P* ≤0.05

Group 1- NC- Normal control. Fed with normal diet without any supplementation

Group 2- PC 1 –Positive control 1 –treated with heated sunflower oil

Group 3-PC 2- Positive control 2–treated with heated sesame oil

Group 4- EX 1-Experimental group 1-treated sunflower oil used to fry the potatoes

Group 5- EX 2-Experimental group 2- treated with sesame oil used to fry the potatoes

Apart from oxidative stress generated in EX groups, there was also a significant reduction in the level plasma HDL along with an increment in the levels of triglyceride; LDL and total cholesterol were also noted. This may be due to the additional supplemented oils in the diet. Free radicals enhance the oxidation of light density lipoprotein (LDL) and oxidized LDL affects many biological processes involved in atherogenesis. A recent study found that a toxin called 4-hydroxy-trans-2-nonenal (HNE) forms when the oils are reheated. Once absorbed in the body, HNE reacts with DNA and proteins affecting basic cellular processes. Frying foods at or above 375oF can lead to the accumulation of 4-hydroxy-trans-2-nonenal (HNE) in the oil. HNE is a toxic substance that has been associated with an increased risk of stroke, atherosclerosis, elevated levels of LDL cholesterol, Alzheimer's, Parkinson's, various liver diseases and cancer [20]. Heating once can create the formation of HNE in the oil, and reusing oil at too high of a heat can cause even more HNE to build-up. Researchers found that HNE is more likely to build up in oils with high levels of linoleic acid. The oil with the highest percentage of linoleic acid is the sunflower oil compared to sesame oil [21].

There are two types of fatty acids that are termed 'essential' because the body cannot produce them. These are omega-3 and omega-6 fatty acids, when the balance of omega-6s and omega-3s in the cell is disturbed, it can cause physiological changes in the cellular functions. The more double bonds in a fatty acid, the more reactive it is. Polyunsaturated fats tend to react with oxygen, which can cause chain reactions, damaging other structures and perhaps even vital structures like DNA [22].

According to our findings we recommend that sesame oil is more advisable to use in cooking than the sunflower oil due to its high smoking point. Sesame seed oil is a potent antioxidant which will neutralize oxygen radicals by scavenging the ROS. *In vitro*, sesame seed oil has inhibited the growth of malignant melanoma so this is used as an anticancer agent. Sesame seed oil is a cell growth regulator and slows down cell growth and replication. Sesame seed oil absorbs quickly and penetrates through the tissues to the very marrow of the bone. It enters into the blood stream through the capillaries and circulates faster. The liver does not sweep sesame seed oil molecules from the blood, accepting those molecules as friendly. Sesame

oil has a lowering effect on blood pressure and levels of sodium in the blood acting as a diuretic [23]. On the other-hand sunflower oil is rich inOmega-6 fatty acids which are harmful in excess with many side effects [24].

5. CONCLUSION

The results of this study demonstrated that sesame seed oil have many protective characteristics when compared to sunflower oil. This is due to its antioxidant potential and rich in Omega-3 fatty acids. Importantly instead of sticking to one type of oil, consumers should try to use different oils always in moderate amounts.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The author hereby declares "Principles of laboratory animal care" (published in 2005) were followed. All experiments have been examined and approved by the appropriate ethics committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Alfred Thomas. Fats and Fatty Oils. Ullmann's Encyclopedia of Industrial Chemistry. Weinheim; 2002. Wiley-VCH.
2. The Culinary Institute of America The Professional Chef. New York: Wiley; 2011. ISBN 0-470-42135-5.
3. Warner K. Impact of high-temperature food processing on fats and oil. *Advances in Experimental Medicine and Biology*. 1999; 459:67-77.
4. Abramovic H, Klofutar C. The temperature dependence of dynamic viscosity for some vegetable oils. *Acta Chim. Slov. (Acta.chem-soc.si)*. 1998;45(1):69-77. (Received 2013-02-07)
5. Che Man YB, Liu JL, Jamilah B, Abdul. Quality changes of RBD palm olein, soybean oil and their blends during deep-fat frying. *Journal of Food Lipids*. 1999; 6(3):181-193.

6. Elleuch M, Besbes S, Roiseux O, Blecker C, Attia H. Quality characteristics of sesame seeds and by-products. *Food Chemistry*. 2007;2:641.
7. Suja KP, Jayalekshmy A, Arumugha C. Antioxidant activity of sesame cake extract. *Food Chemistry*. 2005;91:213.
8. Lim JS, Adachi Y, Takahashi Y, Ide T. Comparative analysis of sesame lignans (sesamin and sesamol) in affecting hepatic fatty acid metabolism in rats. *Br J Nutr*. 2007;97(1):85–95.
9. Yanishlieva NVI, Marinova EM. Effects of antioxidants on the stability of triacylglycerols and methyl esters of fatty acids of sunflower oil. *Food Chemistry*. 1995;54(4):377.
10. De Marco Elena, Savarese Maria, Parisini Cristina, Battimo Ilaria, Falco Salvatore, Sacchi Raffaele. Frying performance of a sunflower/palm oil blend on comparison with pure palm oil. *European Journal of Lipid Science and Technology*. 2007; 109(3):273.
11. Niehaus WG, Samuelson B. Formation of MDA from phospholipid arachidonate during microsomal lipid peroxidation. *European Journal of Biochemistry*. 1986;6: 126-130.
12. Ellman GL. Tissue sulhydryl groups. *Archives of Biochemistry and Biophysics*. 1959;82:70-77.
13. Kakkar P, Das B, Viswanathan PN. A modified spectrophotometric assay of superoxide dismutase. *Indian Journal of Biochemistry and Biophysics*. 1984;21: 130-132.
14. Bisswanger H. *Practical enzymologist*. Wiley-VCH Verlag GmbH & Company, KGaA, Weinheim. 2004;79.
15. Food and nutrition board, institute of medicine of the national academies. *Dietary reference Intakes for Energy*, National Academies Press. 2005;423.
16. Katan, Martijn B, Mozaffarian, Dariush, Micha, Renata, Wallace, Sarah. ed. Effects on coronary heart disease of increasing polyunsaturated fat in place of saturated fat: A systematic review and meta-analysis of randomized controlled trials. *PLoS Medicine*. 2010;7(3):100-25.
17. Aldini G, Dalle-Donne I, Colombo R, MaffeiFacino R, Milzani A, Carini M. Lipoxidation-derived reactive carbonyl species as potential drug targets in preventing protein carbonylation and related cellular dysfunction. *Chem Med Chem*. 2006;1:1045-1058.
18. Fritz KS, Petersen DR. Exploring the biology of lipid peroxidation-derived protein carbonylation. *Chemical Research in Toxicology*. 2011;24:1411-1419.
19. Yanishlieva NVI, Marinova EM. Effects of antioxidants on the stability of triacylglycerols and methyl esters of fatty acids of sunflower oil. *Food Chemistry*. 1995;54(4):377.
20. Uchida K. 4-Hydroxy-2-nonenal: a product and mediator of oxidative stress. *Progress in Lipid Research*. 2003;42:318–343.
21. Mensink RP, Zock PL, Kester AD, Katan MB. Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled trials. *The American Journal of Clinical Nutrition*. 2003;77(5):1146-55.
22. Mozaffarian Dariush, Katan Martijn B, Ascherio Alberto, Stampfer Meir J, Willett Walter C. Trans fatty acids and cardiovascular disease. *New England Journal of Medicine*. 2006;354(15):1601-113.
23. Namiki M. Nutritional functions of Sesame: A review. *Critical Reviews in Food Science and Nutrition*. 2007;47:651-673.
24. Aruna K, Kalpana C, Viswanathan P, Menon VP. Toxic effect of sunflower oil on ethanol treated rats. *Hepatology Research*. 2002;26(12):125-135.

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