

# Possible Metabolic Abnormalities of Lipids in Rabbits Given Amoxicillin Overdose and Raw Cucumber (*Cucumis Sativus*) Fruit Juice

Mathew Folaranmi Olaniyan, Bukunmi Temitayo Olusa<sup>1</sup>

Department of Medical Laboratory Science, Edo University, Iyamho, <sup>1</sup>Department of Medical Laboratory Science, Achievers University, Owo, Nigeria

## Abstract

**Study Background:** Raw cucumber (*Cucumis sativus*) fruit juice contains substances of health benefits. Metabolism of lipids takes place in the liver. Overdose of amoxicillin (an antibiotic) can cause hemolysis, hepatotoxicity, and inflammation. **Aim and Objective:** This work was designed to determine the possible metabolic abnormalities of total cholesterol (T-Chol), total triglycerides (TGs), high-density lipoprotein cholesterol (HDL-Chol), and low-density lipoprotein cholesterol (LDL-Chol) in rabbits given amoxicillin overdose and raw cucumber (*C. sativus*) fruit juice. **Materials and Methods:** Fifteen rabbits of the same sex weighing 0.9–1.4 kg divided into three groups of five rabbits each were used for the study. Group A – Five control rabbits; Group B – Five rabbits given 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h for 7 days which was followed by 30 ml raw cucumber fruit juice supplementation for 14 days; Group C – Five rabbits were given 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h and raw cucumber fruit juice supplementation for 14 days simultaneously. Plasma T-Chol, total TGs, and HDL-Chol were determined in the rabbits biochemically using spectrophotometry. **Results:** The results obtained showed a significant decrease in the plasma T-Chol and HDL-Chol in the rabbits when they were given 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h for 7 days compared with the results obtained in the normal control rabbits, their basal samples, and the results obtained when the rabbits were supplemented with 30 ml raw cucumber fruit juice for 14 days after amoxicillin overdose with  $P < 0.05$ . **Conclusion:** The work showed a significant decrease in the plasma T-Chol and HDL-Chol in the rabbits when they were given overdose of amoxicillin while plasma values of these parameters were significantly increased though not higher than in the control rabbits and basal samples when the rabbits were supplemented with raw cucumber fruit juice.

**Keywords:** Amoxicillin overdose, high-density lipoprotein cholesterol rabbits, raw cucumber (*Cumis sativus*) fruit juice, total cholesterol, total triglycerides

## INTRODUCTION

Cucumber (*Cucumis sativus*) fruit juice has conventional health applications such as treatment of ailments, which include abdominal discomforts, anemia, cancer, insomnia, and diabetes; it has anti-inflammatory and antioxidant properties that can protect brain and ears, treat urinary tract infections, and also act as antiaging.<sup>[1-4]</sup> Cucumber fruit is a good source of disease-preventive phytonutrients, such as flavonoids, lignans, Vitamin K, Vitamin C, magnesium, potassium, manganese, Vitamin A, and triterpenes, which have antioxidant, anti-inflammatory, and anticancer benefits. The peel and seeds are most rich in nutrients.<sup>[5,6]</sup> They contain fiber and beta-carotene, an antioxidant that helps with immunity, skin, eye, and prevention of cancer. Cucumber

fruit is low in calories, carbohydrates, sodium, fat, and cholesterol.<sup>[1-4]</sup>

Amoxicillin is one of the penicillin-antibiotic drugs, which is used to treat bacterial infection of the ear, bladder, or pneumonia, including *Salmonella* infections.<sup>[7-9]</sup> An overdose of amoxicillin may be accidental and unintentional. The symptoms of amoxicillin overdose and side effects include nausea, vomiting, diarrhea, bleeding, jaundice, liver

**Address for correspondence:** Prof. Mathew Folaranmi Olaniyan, Department of Medical Laboratory Science, Edo University, Iyamho, Nigeria. E-mail: olaniyanmat@yahoo.com

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**For reprints contact:** reprints@medknow.com

**How to cite this article:** Olaniyan MF, Olusa BT. Possible metabolic abnormalities of lipids in rabbits given amoxicillin overdose and raw cucumber (*Cucumis sativus*) fruit juice. Matrix Sci Med 2020;4:15-9.

**Received:** 16-12-2019, **Accepted:** 20-01-2020, **Published:** 09-03-2020

### Access this article online

#### Quick Response Code:



**Website:**  
www.matrixscimed.org

**DOI:**  
10.4103/MTSM.MTSM\_29\_19

dysfunction, and kidney dysfunction which can lead to kidney failure.<sup>[7-9]</sup>

Metabolism of cholesterol takes place in the liver. Liver produces cholesterol and excretes it in nonesterified form through bile to the digestive system, which will in turn be reabsorbed through the small intestine back into the circulation.<sup>[10,11]</sup> Low-density lipoprotein (LDL) and high-density lipoprotein (HDL) transport cholesterol. High plasma level of HDL is an indication of good health. HDL transports cholesterol back to the liver for excretion or for other tissue activities.<sup>[10,11]</sup> Large amount of cholesterol is found on LDL. LDL transports fat molecules to the cells which can accumulate to cause atherosclerosis.<sup>[11]</sup> Very low-density lipoprotein (VLDL) is produced by the liver from triacylglycerol and cholesterol. Liver cells produce and store triglycerides (TGs).<sup>[10,11]</sup> The major transport lipoprotein for TGs is VLDL.<sup>[12,13]</sup>

Cucumber (*C. sativus*) fruit contains phytochemicals and phytonutrients of health benefits. Amoxicillin is an antibiotic used to treat infections and can be obtained easily in the market. An overdose could result into hepatotoxicity which may cause abnormal lipids metabolism as lipid metabolism takes place in the liver. There is little information on the possible metabolic abnormalities of lipids in rabbits given amoxicillin overdose and raw cucumber (*C. sativus*) fruit juice, hence the need for this work.

## MATERIALS AND METHODS

### Materials

#### Study area

This work was carried out at the Animal House of Achievers University, Owo, Nigeria. Achievers University is in Owo, Ondo state, Nigeria. The university is a private-sector initiative, established in 2007 and accredited by the National Universities Commission.

#### Study population

Fifteen rabbits of the same sex divided into three groups of five rabbits each were used for the study. The rabbits were bought animal farm in Owo, Nigeria, and was presented to Federal School of Agriculture, Akure, for confirmation.

- Group A – Five control rabbits were fed with normal meal and water throughout the period of investigation
- Group B – Five rabbits given 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h for 7 days (B<sub>2</sub>) which was followed by 30 ml raw cucumber fruit juice supplementation for 14 days (B<sub>3</sub>)
- Group C – Five rabbits given 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h and raw cucumber fruit juice supplementation for 14 days simultaneously.

#### Administration of amoxicillin

Amoxicillin was bought from a registered pharmaceutical shop in Owo, Nigeria. Overdose of 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h for 7 days.

#### Preparation of cucumber (*Cucumis sativus*) fruit juice

Cucumber (*C. sativus*) was bought from fruit vendors in Owo, Nigeria. The fruit was presented to Federal School of Agriculture, Akure, for confirmation. The fruit was washed in sterile water and then sliced. The sliced fruit was blend together using an electronic blender. The raw fluid was extracted using a sterile sieve. The raw liquid extract was served to the rabbits as juice. 30 ml was given to the rabbits on daily basis. Freshly prepared fruit juice was administered throughout the period of this work.

#### Specimen (blood) collection

Five milliliters of venous blood was collected from each of the rabbits into lithium heparinized bottles for the biochemical analysis. The blood samples include:

- A – Blood sample collected from the control rabbits
- B1 – Basal blood sample of Group B rabbits before administration of amoxicillin and cucumber fruit juice
- B2 – Blood sample of Group B rabbits collected after the amoxicillin administration
- B3 – Blood sample of Group B rabbits collected after the rabbits were given cucumber fruit juice following amoxicillin administration (overdose)
- C1 – Basal sample of Group C rabbits collected before administration of amoxicillin and cucumber fruit juice
- C2 – Blood sample of Group C rabbits collected after the rabbits were given cucumber fruit juice and amoxicillin overdose simultaneously.

## Methods

### Biochemical analysis

#### Estimation of low-density lipoprotein cholesterol (Friedewald equation)

Most of the circulating cholesterol is found in three major lipoprotein fractions: VLDL (Very Low Density Lipoprotein), LDL (Low Density Lipoprotein), and HDL (High Density Lipoprotein). TotalChol (Total Cholesterol) = Very Low Density Lipoprotein Cholesterol (VLDLChol) + lowdensity lipoprotein cholesterol (LDLChol) + highdensity lipoprotein cholesterol (HDLChol). LDLChol was calculated from measured values of total cholesterol (TChol), TGs, and HDLChol according to the relationship:

$LDLChol = TChol - HDLChol - TG/5$ , where TG/5 is an estimate of VLDLChol and all values are expressed in mg/dl.

#### High-density lipoprotein cholesterol measurement using Roche diagnostics kit

##### Principle

The method uses sulfated alpha-cyclodextrin in the presence of Mg<sup>2+</sup>, which forms complexes with apoB-containing lipoproteins, and polyethylene glycol (PEG)-coupled cholesteryl esterase and cholesterol oxidase for the HDL-Chol measurement.

The reactions are as follows: (1) ApoB-containing lipoproteins +  $\alpha$ -cyclodextrin + Mg<sup>2+</sup> + dextran SO<sub>4</sub> → soluble nonreactive complexes with

apoB-containing lipoproteins. (2) HDL-cholesteryl esters PEG-cholesteryl esterase > HDL-unesterified cholesterol + fatty acid. (3) Unesterified cholesterol + O<sub>2</sub> PEG-cholesterol oxidase > cholestenone + H<sub>2</sub>O<sub>2</sub>. (4) H<sub>2</sub>O<sub>2</sub> + 5-aminophenazone + N-ethyl-N-(3-methylphenyl)-N'-succinylethylenediamine + H<sub>2</sub>O + H<sup>+</sup> + peroxidase > quinoneimine dye + H<sub>2</sub>O. Absorbance is measured at 600 nm.

### Total cholesterol measurement using Roche diagnostic kit Principle

T-Chol is measured enzymatically in the serum or plasma in a series of coupled reactions that hydrolyze cholesteryl esters and oxidize the 3-OH group of cholesterol. One of the reaction byproducts, H<sub>2</sub>O<sub>2</sub> is measured quantitatively in a peroxidase catalyzed reaction that produces a color. Absorbance is measured at 500 nm. The color intensity is proportional to cholesterol concentration.

The reaction sequence is as follows: cholesteryl ester hydrolase cholesteryl ester + H<sub>2</sub>O → cholesterol + fatty acid  
cholesterol oxidase cholesterol + O<sub>2</sub> → cholest-4-en-3-one + H<sub>2</sub>O<sub>2</sub>  
peroxidase 2H<sub>2</sub>O<sub>2</sub> + 4-aminophenazone + phenol → 4-(p-benzoquinonemonoimino)-phenazone + 4 H<sub>2</sub>O.

### Total triglycerides using Roche diagnostics kit Principle

TGs were measured enzymatically in the plasma using a series of coupled reactions in which TGs are hydrolyzed to produce glycerol. Glycerol is then oxidized using glycerol oxidase, and H<sub>2</sub>O<sub>2</sub>, one of the reaction products, is measured as described above for cholesterol. Absorbance is measured at 500 nm. The reaction sequence is as follows: lipase TGs + 3H<sub>2</sub>O → glycerol + fatty acids  
glycerokinase glycerol + ATP → glycerol-3-phosphate + ADP  
glycerophosphate oxidase Glycerol-3-phosphate + O<sub>2</sub> → dihydroxyacetone phosphate + H<sub>2</sub>O<sub>2</sub>  
peroxidase H<sub>2</sub>O<sub>2</sub> + 4-aminophenazone + 4-chlorophenol → 4-(p-benzoquinone-monoimino)-phenazone + 2H<sub>2</sub>O + HCl.

### Method of data analysis

Statistical Package for Social Sciences IBM SPSS 18.0 version (IBM SPSS, New York) was used for the analysis of the data to determine mean, Student's *t*-test and probability at 95% confidence interval and 0.05 level of significance.

## RESULTS

The results obtained showed a significant decrease in the plasma T-Chol and HDL-Chol in the rabbits when they were given 30.0 mg/kg BW subcutaneous injection of amoxicillin every 24 h for 7 days compared with the results obtained in the normal control rabbits, their basal samples, and the results obtained when the rabbits were supplemented with 30 ml raw cucumber fruit juice for 14 days after amoxicillin overdose with *P* < 0.05 [Tables 1 and 2 and Figure 1].

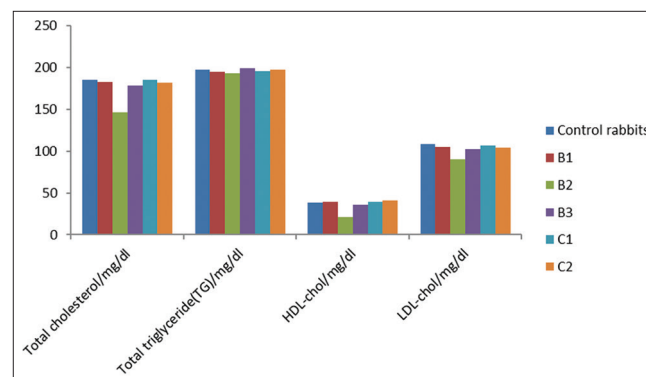
No significant difference was obtained in the plasma values of total TG and LDL-Chol in the rabbits before and after

amoxicillin overdose and supplementation with 30 ml raw cucumber fruit juice; further, no significant difference was obtained in the plasma values of total TG and LDL-Chol in the experimental rabbits compared with the results obtained from the control rabbits with *P* > 0.05 [Tables 1 and 2 and Figure 1]. There was no significant difference in the plasma values of T-Chol, total TG, HDL-Chol, and LDL-Chol in the rabbits when they were given 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h together with raw cucumber fruit juice for 14 days (*P* > 0.05) [Tables 1 and 2 and Figure 1].

## DISCUSSION

The results obtained showed a significant decrease in plasma T-Chol and HDL-Chol in the rabbits when they were given 30 mg/kg BW subcutaneous injection of amoxicillin every 24 h for 7 days compared with the results obtained in the normal control rabbits, their basal samples, and the results obtained when the rabbits were supplemented with 30 ml raw cucumber fruit juice for 14 days after amoxicillin overdose. In this study, low cholesterol and HDL-Chol could be associated with amoxicillin overdose-induced hepatotoxicity and inflammation, which might have resulted into decreased lipid metabolic function of the liver causing reduction in the synthesis of cholesterol in the hepatocytes because about 80% of total daily cholesterol production occurs in the liver; cholesterol content in the bloodstream is also regulated by the liver. After a meal, cholesterol in the diet is absorbed from the small intestine and metabolized and stored in the liver as the body requires cholesterol; it may also be secreted by the liver.<sup>[13-18]</sup>

Another potent reason for the above findings is the fact that decrease in HDL-Chol may cause a decrease in the concentration of plasma cholesterol as studies have shown that HDL-lacking mice still have the ability to transport cholesterol to bile, suggesting that there are alternative mechanisms for cholesterol removal.<sup>[19]</sup> Another reason for decrease in HDL-Chol is that HDL-Chol scavenges and removes LDL-Chol or "bad" – cholesterol. HDL reduces, reuses, and recycles LDL-Chol by transporting it to the liver where it can



**Figure 1:** Comparative description of the mean and standard deviation of plasma values of total cholesterol, total triglyceride, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol obtained in the rabbits

**Table 1: Plasma values of total cholesterol, total triglyceride, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol obtained in the rabbits**

	Control rabbits A	Group				
		B			C	
		B1	B2	B3	C1	C2
T-Chol/mg/dl (mean±SD)	185±6.0	183±5.0	146±7.0	178±5.0	185±5.0	182±4.0
TG/mg/dl (mean±SD)	197±8.0	195±6.0	193±5.0	199±4.0	196±6.0	197±5.0
HDL-Chol/mg/dl (mean±SD)	38±3.0	39±4.0	21±2.0	36±4.0	39±3.0	41±1.0
LDL-Chol/mg/dl (mean±SD)	108±5.0	105±5.0	90±6.0	102±4.0	107±4.0	104±3.0

TG: Triglyceride, HDL-Chol: High-density lipoprotein cholesterol, LDL-Chol: Low-density lipoprotein cholesterol, T-Chol: Total cholesterol, SD: Standard deviation

**Table 2: Comparative analysis of the mean and standard deviation of plasma values of total cholesterol, total triglyceride, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol obtained in the rabbits**

	A versus B1	A versus B2	A versus B3	A versus C1	A versus C2	B1 versus B2	B1 versus B3	B2 versus B3	C1 versus C2
T-Chol/mg/dl (t, P)	0.256, 0.42	4.23014, 0.026*	0.896, 0.232	0, 0.5	0.791, 0.26	4.30, 0.03*	0.71, 0.28	-3.72, 0.033*	0.4685, 0.343
TG/mg/dl (t, P)	0.2, 0.43	0.424, 0.356	0.224, 0.422	0.1, 0.47	0.056, 0.48	0.256, 0.411	0.224, 0.422	-0.94, 0.22	-0.128, 0.455
HDL-Chol/mg/dl (t, P)	-0.2, 0.43	4.715, 0.02*	0.4, 0.36	-0.24, 0.42	-0.95, 0.222	4.03, 0.03*	0.53, 0.324	3.354, 0.039*	-0.63, 0.296
LDL-Chol/mg/dl (t, P)	0.42, 0.356	2.31, 0.074	0.94, 0.224	0.156, 0.45	0.686, 0.28	1.63, 0.123	0.47, 0.343	-1.66, 0.12	0.6, 0.3047

\*Significant. A: Blood sample collected from the control rabbits, B1: Basal blood sample of Group B rabbits before administration of amoxicillin and cucumber fruit juice, B2: Blood sample of Group B rabbits collected after the amoxicillin administration, B3: Blood sample of Group B rabbits collected after the rabbits were given cucumber fruit juice following amoxicillin administration (overdose), C1: Basal sample of Group C rabbits collected before administration of amoxicillin and cucumber fruit juice, C2: Blood sample of Group C rabbits collected after the rabbits were given cucumber fruit juice and amoxicillin overdose simultaneously. TG: Triglyceride, HDL-Chol: High-density lipoprotein cholesterol, LDL-Chol: Low-density lipoprotein cholesterol, T-Chol: Total cholesterol

be reprocessed. HDL-Chol acts as a maintenance crew for the inner walls (endothelium) of blood vessels. Damage to the inner walls is the first step in the process of atherosclerosis, which causes heart attacks and strokes. HDL scrubs the wall clean and keeps it healthy. The abnormal decrease in T-Chol and HDL-Chol could be as a result of excessive utilization of cholesterol in possible amoxicillin-induced hepatotoxicity/inflammation, as cholesterol is an essential fat that provides stability in every cell of the body. HDL and its protein and lipid constituents help to inhibit oxidation, inflammation, activation of the endothelium, coagulation, and platelet aggregation. All these properties may contribute to the ability of HDL to protect from atherosclerosis, and it is not yet known which are the most important.<sup>[20]</sup>

This could also be attributed to lipid peroxidation induced by amoxicillin overdose, which involves the oxidative degradation of lipids. It is the process in which free radicals “steal” electrons from the lipids in cell membranes, resulting in cell damage. This process proceeds by a free radical chain reaction mechanism. Lipid peroxidation is a mechanism of cell injury by chemicals such as drugs.<sup>[21,22]</sup> Lipid peroxidation can be the direct consequence of drug-derived radical formation or may appear concomitantly after previous Glutathione (GSH) depletion as the result of the cell’s inability to protect itself from active oxygen species generated during cellular oxidative metabolism.<sup>[21,22]</sup>

Significant increase in total plasma and HDL-Chol though not higher than the results obtained in the control rabbits and the basal samples could be related to the antioxidative and antitoxin properties of the phytochemicals and phytonutrient constituents of raw cucumber fruit juice because the pulp can even offer anti-inflammatory and antioxidant properties.<sup>[1-4]</sup> Cucumber fruit contains phytonutrients (plant chemicals that have protective or disease preventive properties) such as flavonoids, lignans, and triterpenes, which have antioxidant, anti-inflammatory, and anticancer benefits. Cucumber fruit also contains fiber, beta-carotene, Vitamin C, small amounts of Vitamin K, Vitamin C, magnesium, potassium, manganese, and Vitamin A and is naturally low in calories, carbohydrates, sodium, fat, and cholesterol.<sup>[1-4,6]</sup> It contains Vitamin E and Vitamin C for neutralizing free radicals.<sup>[21]</sup>

## CONCLUSION

The work showed a significant decrease in plasma T-Chol and HDL-Chol in the rabbits when they were given overdose of amoxicillin while plasma values of these parameters were significantly increased though not higher than in the control rabbits and basal samples when the rabbits were supplemented with raw cucumber fruit juice.

## Recommendation

Raw cucumber fruit juice could be taken as the first aid antidote

in drug misuse/overdose, including evaluation of lipid profile in drug overdose.

### Financial support and sponsorship

Nil.

### Conflicts of interest

There are no conflicts of interest.

## REFERENCES

- Buchanan D. Taste, Memory: Forgotten Foods, Lost Flavors, and Why They Matter. VT, USA: Chelsea Green Publishing; 2012. p. 109.
- Kuhnlein HV, Turner NJ. Traditional Plant Foods of Canadian Indigenous Peoples: Nutrition, Botany and Use. Amsterdam, Netherlands: Gordon and Breach; 1996. p. 159.
- Huang S, Li R, Zhang Z, Li L, Gu X, Fan W, *et al.* The genome of the cucumber, *Cucumis sativus* L. *Nat Genet* 2009;41:1275-81.
- Schieberle P, Ofner S, Grosch W. Evaluation of potent odorants in cucumbers (*Cucumis sativus*) and muskmelons (*Cucumis melo*) by aroma extract dilution analysis. *J Food Sci* 1990;55:193.
- James PJ, Thorpe N, Thorpe IJ. Ancient Inventions "Sport and Leasure: Roman Gardening Technology. Ch. 12. Publisher: Ballantine Books; New York City, New York Reprint edition, 1995. p. 563.
- Shang Y, Ma Y, Zhou Y, Zhang H, Duan L, Chen H, *et al.* Plant science. Biosynthesis, regulation, and domestication of bitterness in cucumber. *Science* 2014;346:1084-8.
- Fischer J, Ganellin CR. Analogue-based Drug Discovery. Publisher: John Wiley and Sons, USA; 2006. p. 490.
- Gillies M, Ranakusuma A, Hoffmann T, Thorning S, McGuire T, Glasziou P, *et al.* Common harms from amoxicillin: A systematic review and meta-analysis of randomized placebo-controlled trials for any indication. *CMAJ* 2015;187:E21-31.
- Rhodes CM, Stryer L, Tasker R. *Biochemistry*. 4<sup>th</sup> ed. San Francisco: W.H. Freeman; 1995. p. 280, 703.
- Berg J. *Biochemistry*. New York: WH Freeman; 2002.
- O'Keefe JH Jr., Cordain L, Harris WH, Moe RM, Vogel R. Optimal low-density lipoprotein is 50 to 70 mg/dl: Lower is better and physiologically normal. *J Am Coll Cardiol* 2004;43:2142-6.
- Shelness GS, Sellers JA. Very-low-density lipoprotein assembly and secretion. *Curr Opin Lipidol* 2001;12:151-7.
- Gibbons GF, Wiggins D, Brown AM, Hebbachi AM. Synthesis and function of hepatic very-low-density lipoprotein. *Biochem Soc Trans* 2004;32:59-64.
- Razin S, Tully JG. Cholesterol requirement of mycoplasmas. *J Bacteriol* 1970;102:306-10.
- Hanukoglu I. Steroidogenic enzymes: Structure, function, and role in regulation of steroid hormone biosynthesis. *J Steroid Biochem Mol Biol* 1992;43:779-804.
- Dubois C, Armand M, Mekki N, Portugal H, Pauli AM, Bernard PM, *et al.* Effects of increasing amounts of dietary cholesterol on postprandial lipemia and lipoproteins in human subjects. *J Lipid Res* 1994;35:1993-2007.
- Behrman EJ, Gopalan V, Scovell WM. Cholesterol and plants. *J Chem Educ* 2005;82:1791.
- Lecerf JM, de Lorgeril M. Dietary cholesterol: From physiology to cardiovascular risk. *Br J Nutr* 2011;106:6-14.
- Sirtori SS, Cesare R. HDL and the progression of atherosclerosis: New insights. *Eur Heart J Suppl* 2006;8:F4-9.
- Stephens NA, Kieft R, Macleod A, Hajduk SL. Trypanosome resistance to human innate immunity: Targeting Achilles' heel. *Trends Parasitol* 2012;28:539-45.
- Ostrea EM Jr., Cepeda EE, Fleury CA, Balun JE. Red cell membrane lipid peroxidation and hemolysis secondary to phototherapy. *Acta Paediatr Scand* 1985;74:378-81.
- Benzie IF. Lipid peroxidation: A review of causes, consequences, measurement and dietary influences. *Int J Food Sci Nutr* 1996;47:233-61.