INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 10, No. 1, p. 374-381, 2017

RESEARCH PAPER OPEN ACCESS

Efficacy study of ginger and garlic mixture on hypoglycaemic and hyperlipidemic parameters of induced diabetic mice

Amna Masroor[1], Rai Muhammad Amir*[2], Fiza Komal[1], Muhammad Adnan Nasir[3], Furukh Faiz[4]

[1]*Institute of Home and Food Sciences, Government College University, Faisalabad, Pakistan*

[2]*Department of Food Technology, PMAS-Arid Agriculture University, Rawalpindi, Pakistan*

[3]*Department of Food Science and Technology, Islamia University of Bahawalpur, Pakistan*

[4]*Department of Agriculture and Food, Karakoram International University, Gilgit-Baltistan, Pakistan*

Key words: Alloxan, diabetes, Garlic and ginger mixture, Blood glucose, Lipid profile

http://dx.doi.org/10.12692/ijb/10.1.374-381 Article published on January 31, 2017

Abstract

The raw garlic (*A. sativum*) and ginger (*Z. officinale*) mixture at 1:1 ratio have been used to estimate its effects on diabetes and cholesterol level by using alloxan induced diabetic mice. For that purpose, 25 mice were used, the mice were kept in controlled room by maintaining room temperature about 25±1°C and relative humidity about 45-55% under 12hr light and 12hr dark cycle. Intraperitoneal injections of aqueous alloxan monohydrate (40mg/kg) were used to induce diabetes in mice. The experimental mice were divided into five groups where G_1 (Control normal), G_2 (Diabetic control mice), G_3 (10g/100g diet), G_4 (15g/100g diet), G_5 (30g/100g diet) each diet have 50% garlic and 50% ginger. Data was collected daily to check the effects on garlic and ginger on blood glucose and at the end of experiment mice were killed to collect blood sample and was analyzed for lipid profile. Resulted data depicted that a significant decline in blood glucose was observed in G_2 after 72hrs. In G_5 maximum decline trend regarding blood glucose was observed. Additionally, significant effect of mixture on high density lipo protein (HDL), Low density lipoprotein (LDL) and triglycerides in G_3, G_4 and G_5 was observed. Statistical results depicted that LDL and triglycerides were decreased, on the other hand significant increases in HDL level were observed. Moreover, G_3 exhibited maximum reduction in cholesterol, LDL and triglyceride level. Conclusively it has been observed that the consumption of garlic and ginger mixture created a beneficial hypoglycaemic and hyperlipidemic effect in diabetic induced mice.

* **Corresponding Author:** Rai Muhammad Amir ✉ raiamir87@yahoo.com

Introduction

Diabetes and its associated diseases are one of the prominent menaces of developing countries. The numbers of diabetic peoples are increasing because of various factors such as increasing in occurrence of obesity and physical inactivity, increasing in population, aging, as well as the urbanization. With the increasing in the numbers of diabetic peoples, at the end of 2030 Pakistan will be at 6th number, according to the information about 376 million people's will be distressed (Wild *et al.,* 2004).

It is a metabolic disorder that progressively distresses various physiological mechanisms of the body. It is one of the prominent reasons for death and, if leave for uncontrolled blood glucose level, can damage various body organs specially kidney (Zakir *et al.,* 2008). In diabetic patient unchecked blood glucose is thought to be the fundamental aspect in the inception of diabetic complications in both conditions either type 1 or type 2 diabetes (Educators, 2002). Common type is Type 2, whereas Type 1 diabetes develops in early stages of life especially in childhood. Main causes for Type 2 are energy rich diet, sedentary lifestyles, obesity as well as lack of exercise (Yajnik, 2001).

Diabetes is specifically characterized by comparative insufficiency in secretion of insulin or its mode of action linked with hyperglycemia and malfunctioning in the breakdown of lipid, protein or carbohydrate. Additionally, it can cause numerous impediments such as cardiovascular problems, oxidative stress and immune disorder can also develop (Rana *et al.,* 2007). Cardiovascular problems and allied risks are the protuberant reasons of mortality and morbidity in all over the world. Increased in level of cholesterol and LDL oxidation prompt happening that initiate atherosclerosis (Matsuura *et al.,* 2008).

To overcome these circumstances various herbal remedies for diabetes and its allied ailments have been developed (Alarcon-Aguilara *et al.,* 1998). Drug treatment is compulsory with the passage of time it escorted numerous side effects and their efficiency declines (Zakir *et al.,* 2008).

Garlic is an important vegetable, commonly consumed as flavoring or for seasoning in cooking of various food products and in herbal medications (Rivlin, 2001). Garlic has been unveiled to have vibrant biological actions containing antithrombotic, ant diabetic, ant carcinogenic and numerous other biological functions (Augusti, 1996; Augusti and Sheela, 1996). Scientific studies have portrayed that it comprises 30% carbohydrates, 65% water additionally 5% of remaining bioactive constituents principally sulfur comprising compounds (Milner, 2001). It's imperative components are categorized as nonsulfur and sulfur containing components, encompassed by organosulphur compounds particularly thiosulfinates and cysteine sulfoxides have superior importance (Tapiero *et al.,* 2004). Among thiosulfates are S-allay cysteines and from which allicin contribute 60-80% as compare to cystein (Lawson *et al.,* 2001). It have been reported that garlic have potential to lower cholesterol, and helpful for the reduction in blood pressure as well as to control high level of blood glucose (Sterling and Eagling, 1997).

Anti-hyperglycemic effects of garlic have been evaluated and confirmed (Eidi *et al.,* 2006). Various active compounds in garlic may possibly act on blood glucose through different mechanisms and consequently directly decrease blood glucose level by stimulating glycogen Isis and stopping.

Gluconeogenesis and glycogenolysis in muscles and hepatic (Isoken, 2010). The fiber present in garlic might also hinder absorption of carbohydrate, thus distressing level of blood glucose (Jelodar *et al.,* 2005). Antioxidant possessions of garlic are alternative conceivable mechanism that makes it a candidate as ant diabetic agent (Queiroz *et al.,* 2009).

Antioxidant accomplishment of S-allyl cysteine sulfoxide, is deliberated to have antiglycation properties. Various supplementations of garlic embrace significant effect on cholesterol level, LDL and HDL cholesterol and also endow to the stoppage of atherosclerosis (Lau, 2006). Extract of garlic reveal antioxidant and hypoglycemic properties to lower the liver and renal injury (El-Demerdash *et al.,* 2005).

Ginger is likewise very effective to bringing down blood glucose level, triglyceride as well as cholesterol triglyceride levels (Bhandari and Pillai, 2005). In local language ginger (*Zingiber officinale*) is generally named as "Adrak" which belongs to *Zingiberaceae*.

It is utilized in different ways as additive for flavoring and as well as medicine for the treatment of different complications including high cholesterol level, headache (migraine), hepatotoxicity, nausea, burns, peptic ulcer, motion sickness and in case of vomiting (Robbers and Tyler, 1999). It has been evaluated that chemical composition of ginger are β-phellandrene, camphene, zingiberine, cineol and gingrol which have different medicinal importance (Shinwari *et al.,* 2006).

It has been elucidated that solvent extract of ginger has various health benefits specially have effects against blood glucose and cholesterol level. Results depicted that ethyl acetate extract of ginger reduce significantly blood glucose and also increase blood HDL level and ultimately reduce total cholesterol furthermore it also prevented lipid peroxidation tissues and depicted lipid lowering action in diabetes induces rats (Goyal and Kadnur, 2006). Acute quantity of aqueous extracts of *Z. officinale* rhizome illustrated hypoglycaemic activity (Kalejaiye *et al.,* 2002). It also shows a key role in removal of glucose in insulin receptive tissues, which is vital in maintaining blood glucose homeostasis (Li *et al.,* 2012).

Researchers have found that numerous plant products exhibited unique actions against some ailment conditions in diabetic animal model and Pakistan is blessed with many of these curative plants which have been used for the treatment of various diseases. The objective of this study was to inspect the efficiency of garlic and ginger mixture in controlling elevation of blood glucose levels and lipid profile in the alloxan-induced diabetic mice.

Materials and methods

The research work was done in animal room present in National Institute of Food Science and Technology, University of Agriculture, Faisalabad.

Raw material

The available varieties of garlic (*A. sativum*) and ginger (*Z. officinale*) were purchased from the Ayub Agricultural Research Institute, Faisalabad. The garlic and ginger were grinded separately and mixed with equal proportion.

Animal model

For the current study 25 mice were obtained from NIH (National Institute of Health, Islamabad) and kept in the animal room. The room temperature was maintained at of 25±1°C and 45 to 55% relative humidity for 24hrs (12-h light: 12-h dark cycle). Mice kept with normal diet and water *ad libitum* for one week before the start of experiment.

Induction of diabetes

Mice were treated with single intraperitoneal injection of aqueous alloxan monohydrate (40 mg/kg) solution to induce diabetes. After 72hrs serum glucose level of injected mice was above 180mg/dl (diabetic) which were used as diabetic mice.

Sample size

The experimental animals carefully kept in different cages which was randomly divided into 5 groups; having five mice in each group and in mice of each group were placed separately by making five sections in cage: G_1 (Control normal), G_2 (Diabetic control mice), G_3 (10g/100g diet), G_4 (15g/100g diet), G_5 (30g/100g diet) each diet have 50% garlic and 50% ginger. Blood glucose level of all treated mice including normal control and diabetic control groups was checked weekly. At the end of the trail, the mice were slaughtered and blood samples were obtained for analyzing of lipid profile.

Analytical methods

Blood glucose was determined by glucose glucometer Accuchek Active®. Plasma total cholesterol was checked using the CHOD-PAP method followed by (Stockbridge *et al.,* 1989), HDL-cholesterol was estimated by HDL Cholesterol Precipitant method (Assmann, 1979) while LDL-cholesterol and triglycerides were determined by methods as described by McNamara *et al.* (1990) and Annoni *et al.* (1982) respectively.

Statistical analysis

All the data obtained were statistically analyzed for mean and standard deviation. Statistical analysis was carried out using SPSS (Version 17). Comparison of means among groups was performed via one-way analysis of variance (ANOVA) (Steel *et al.,* 1997)

Results and discussion

From this study it was noted that the diabetic mice treated with garlic and ginger mixture showed remarkable decline in blood glucose level after 72h compare to the diabetic control diabetic rats.

Maximum blood glucose reduction was seen in G_5 (143.00±10.48) this significant reduction may lead to hypoglycemia (Table 1). This reduction may be due to garlic and ginger intake caused β cells of pancreas to produce more insulin, which caused the conversion of glucose into glycogen that resulted in decreased blood glucose level (Guyton and Hall, 2000).

Table 1. Effect of garlic and ginger mixture on blood glucose of diabetic induced mice.

Duration	Groups				
	G1 (Control)	G2 (Diabetic)	G3 (g+G* /10g)	G4 (g+G /20g)	G5 (g+G /30g)
First Day	98.80±14.08^{b}	186.80±14.97^{a}	196.40±15.52^{a}	204.40±20.81^{a}	190.00±18.09^{a}
1st Week	95.00±10.81^{b}	204.00±14.38^{a}	188.40±14.64^{a}	186.00±13.91^{a}	174.00±13.54^{a}
2nd Week	98.00±8.60^{b}	193.00±12.41^{a}	178.00±10.26^{a}	180.40±11.18^{a}	168.00±8.74^{ab}
3rd Week	97.00±9.94^{c}	197.00±13.93^{a}	171.00±9.02^{ab}	169.00±11.64^{ab}	156.00±10.25^{b}
4th Week	102.00±11.02^{c}	202.10±16.77^{a}	161.00±11.55^{b}	156.00±10.48^{b}	143.00±10.48^{c}

Results of this study were resembled with data obtained by Ahmed and Sharma (1997) as they studied the effect of garlic and ginger mixture in reducing blood glucose in Wister rats and found the significant decline in the level of blood glucose and elevation in insulin level. Helal *et al.,* (2012) also explored that rats having fatty liver pre and post treated with ginger depicted the reduced serum glucose level. Ginger treatment given for 30 days to streptozotocin induced diabetic rats showed significant decrease in increased blood sugar level (Ramudu *et al.,* 2011).

A garlic study conducted by Johnson *et al.* (2012) on alloxan induced diabetic rats gave same result as serum glucose level was decreased in diabetic rats after giving garlic extract for 3 weeks to pretreated rats and for 2 weeks to post treated diabetic rats. The dose of 300mg/kg body weight of an aqueous extract of garlic was significant in lowering the blood sugar level in alloxan induced diabetic rats (Jevas 2011). Ashour *et al.* (2011) resulted that orally given 200 mg garlic oil according to per kg body weight exhibited drastic increase in serum insulin level. Contrary findings were reached by Jain *et al.* (1993), Mansell *et al.* (1996) and Afkhami-Ardekani *et al.* (2006) who concluded that garlic had no effect on blood sugar. Effect of garlic and ginger mixture on cholesterol, HDL, LDL and triglycerides level in diabetic mice of G_3, G_4 and G_5 was significant showed in Table 2.

Table 2. Effect of garlic and ginger mixture on lipid profile of diabetic induced mice.

Parameters	Groups				
	G1 (Control)	G2 (Diabetic)	G3 (g+G* /10g)	G4 (g+G /20g)	G5 (g+G /30g)
Cholesterol (mg/dl)	151.40±9.79^{b}	215.00±21.99^{a}	187.00±11.07^{ab}	176.60±11.07^{ab}	160.00±8.55^{b}
HDL (mg/dl)	47.80±6.79^{a}	21.80±3.64^{b}	29.60±5.64^{b}	37.20±5.78^{ab}	49.60±5.68^{a}
LDL (mg/dl)	119.40±27.28^{b}	198.80±14.41^{a}	184.80±9.61^{a}	173.00±13.69^{a}	160.80±11.26^{ab}
Triglycerides (mg/dl)	100.6±21.62^{b}	196.60±22.37^{a}	179.80±15.29^{a}	169.20±15.49^{a}	157.40±12.62^{a}

Diabetic control mice showed higher level of cholesterol, LDL and triglycerides while low level of HDL. After giving 10, 20 and 30g mixture of garlic and ginger mixture the level of cholesterol, LDL and triglycerides were decreased whereas, significant increase in HDL level was seen in Table 2.

Most effective dose was 30g which showed the maximum reduction in cholesterol, LDL and triglyceride level of mice of G_3 but exhibited higher and normal level of HDL. The results of this parameter resembled with results of study conducted by Ahmed and Sharma (1997) and Ademola *et al.* (2009) who revealed that rats diet containing combination of ginger plus garlic for 4 weeks significantly decreased total cholesterol and increased HDL showing that mixture of these are more effective in reducing total lipids.

Mice exhibited decreased serum cholesterol, triglycerides and LDL level while increased HDL level when fed on ginger including diet (Hussein, 2012). Comparative results depicted that ginger has better although not significant preventive effect on systolic blood pressure and garlic has better preventive effect on lipid levels (Sanghal *et al.,* 2012). Sterling and Eagling (1997) found that garlic has beneficial effects in reducing total plasma cholesterol and lowering blood pressure. Garlic consists of many organosulpher compounds like allin, allicin, s-allyl cysteine and ajoene (Agarwal, 1996). Most of these compounds inhibit the cholesterol production from hepatocytes (Gebhardt and Beck, 1996). The above mentioned components inhibit the crucial enzyme (3-hydroxy-3-methyl-glutaryl-coenzyme A, HMG-coA, reductase) required in the cholesterol biosynthesis (Ferri *et al.,* 2003; Liu and Yeh 2002). Garlic-derived compounds may also inhibit other enzymes in cholesterol biosynthesis pathway, like sterol 4-alpha-methyl oxidase (Liu and Yeh, 2002).

The results of this study were in favour of Bhandari and Pillai (2005) and Andallu *et al.,* (2003). It has been suggested that ginger chemical components like (E)-8 , 17-epoxylabd-12-ene-15, 16 diol inhibits the biosynthesis of cholesterol (Tapiero *et al.,* 2004). Another mechanism of cholesterol reduction is that supplementation of ginger enhances the activity of LDH receptors which in turn increase the elimination of LDL from plasma thus causing reduction in plasma cholesterol level (Ness *et al.,* 1996).

The results of present study were not in consensus with Sambaiah and Srinivasan (1991) who recorded no change in cholesterol content of rats fed ginger for 56 days. Carrijo *et al.* (2005) reported that garlic powered did not alter the serum levels of cholesterol and triacylglycerol's after feeding broiler chicks so, the results of this research are contradictory to present findings. Bordia *et al.* (1995) also found that 4g ginger powder for 3 months did not show any significant difference in lipid levels. This difference in results may be due to different feeding periods and quantity of mixture fed to mice.

Conclusion

Based upon this research it can be concluded that supplementation of garlic and ginger mixture can decrease blood sugar level, the total serum cholesterol, LDL (low density lipoprotein) and triglycerides in diabetes as well as can increase HDL (high density lipoprotein) which is good cholesterol. This supplementation also has the ameliorative effect on diabetic induced complication related to kidney and liver. But higher dose can exert toxic effect on the body.

References

Ademola S, Farinu G, Babatunde G. 2009. Serum lipid, growth and hematological parameters of broilers fed garlic, ginger and their mixtures. World Journal of Agricultural Sciences **5,** 99-104.

Afkhami-Ardekani M, Kamali-Ardekani A, Shojaoddiny-Ardekani A. 2006. Effects of garlic on serum lipids and blood glucose of type 2 diabetic patients International Journal of Diabetes in Developing Countries **26,** 86-88.

Agarwal KC. 1996 Therapeutic actions of garlic constituents. Medicinal Research Reviews 16**,** 111-124.

Ahmed R, Sharma S. 1997. Biochemical studies on combined effects of garlic (*Allium sativum* Linn) and ginger (*Zingiber officinale* Rosc) in albino rats. Indian journal of experimental biology **35,** 841-843.

Alarcon-Aguilara F, Roman-Ramos R, Perez-Gutierrez S, Aguilar-Contreras A, Contreras-Weber C, Flores-Saenz J. 1998. Study of the anti-hyperglycemic effect of plants used as antidiabetics Journal of Ethnopharmacol **61,** 101-110.

Andallu B, Radhika B, Suryakantham V. 2003. Effect of Aswagandha, ginger and mulberry on hyperglycemia and hyperlipidemia. Plant Foods Human Nutrition **58,** 1-7.

Annoni G, Botasso B, Ciaci D, Donato M, Tripodi A. 1982. Liquid triglycerides (GPO-PAP). Medi Diagnostic Italy. Journal of Laboratory and Clinical. Med **9,** 115.

Ashour MN, Megahed HA, Eltoukhy S, Youness E, Habib D, Wafai H. 2011. Antioxi dant and radical scavenging properties of garlic oil in streptozotocin induced diabetic rats Australian journal of basic and applied sciences **5,** 280-286.

Assmann G. 1979. HDL-cholesterol precipitant. Randox Labs. Ltd. Crumlin Co. Antrim, N. Ireland Internist 20, 559.

Augusti K, Sheela C. 1996. Antiperoxide effect of S-allyl cysteine sulfoxide, an insulin secretagogue, in diabetic rats. Experientia **52,** 115-119.

Augusti K. 1996. Therapeutic values of onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) Journal of Experimental Biology **34,** 634-640.

Bhandari U, Pillai K. 2005. Effect of ethanolic extract of *Zingiber officinale* on dyslipidaemia in diabetic rats. Journal of Ethno pharmacology **97,** 227-230.

Bordia A, Arora SK. Kothari LK. Jain KC. Ratore AS. Dube K, Bhu N. 1997. The protective action of essential oils of onion and garlic in cholesterol-fed rabbits. Atherosclerosis **22,** 103-110.

Carrijo AS, Madeira LA, Sartori JR, Pezzato AC, Goncalves JC, Cruz VC. Kuibida KV, Pinheiro DF. 2005. Powdered garlic in the alternative feeding of broiler chickens. Pesquisa Agropecuaria Brasileira **40,** 673-679.

Educators AAOD. 2002. Intensive diabetes management: implications of the DCCT and UKPDS. The Diabetes Educator **28,** 735.

Eidi A, Eidi M, Esmaeili E. 2006. Antidiabetic effect of garlic (*Allium sativum* L.) in normal and streptozotocin-induced diabetic rats. Phytomedicine **13,** 624-629.

El-Demerdash F, Yousef M, El-Naga NA. 2005. Biochemical study on the hypoglycemic effects of onion and garlic in alloxan-induced diabetic rats. Food Chemical Toxicology **43,** 57-63.

Ferri N, Yokoyama K, Sadilek M, Paoletti R, Apitz-Castro R, Gelb MH, Corsini A. 2003 Ajoene, a garlic compound, inhibits protein prenylation and arterial smooth muscle cell proliferation British journal of pharmacology and chemotherapy **138,** 811-818.

Gebhardt R, Beck H. 1996. Differential inhibitory effects of garlic-derived organ sulfur compounds on cholesterol biosynthesis in primary rat hepatocyte cultures. Lipids **31,** 1269-1276.

Goyal RK, Kadnur SV. 2006. Beneficial effects of *Zingiber officinale* on Goldthioglucose induced obesity. Fitoterapia **77,** 160-163.

Guyton A, Hall J. 2000. Textbook of Medical Physiology 10th Edn (Philadelphia, PA: WB Saunders),

Helal EG, El-Wahab SMA, Sharaf AMM, Zedan GA. 2012. Effect of *Zingiber officinale* on fatty liver induced by oxytetracycline in albino rats. Egyptian Journal of Hospital Medicine **46,** 26-42.

Hussein MAA. 2012, The effect of ginger (*Zingibar officinale*) aqueous extract on some biochemical parameters and kidney function in male mice Kufa Medical Journal **15,** 273-278.

Isoken M. 2010. Blood glucose and morphology of the liver and pancreas in garlic fed Wistar rats. Journal of Medicinal Plants Research **4,** 1877-1882.

Jain AK, Vargas R, Gotzkowsky S, McMahon FG. 1993. Can garlic reduce levels of serum lipids? A controlled clinical study. American Journal of Medicine **94**, 632-635.

Jelodar GA, Maleki M, Motadayen M, Sirus S. 2005. Effect of fenugreek, onion and garlic on blood glucose and histopathology of pancreas of alloxan-induced diabetic rats. Indian Journal of Medical Science **59,** 64.

Jevas C. 2011 Anti-diabetic effects of *Allium cepa* (onions) aqueous extracts on alloxan-induced diabetic Rattus novergicus Journal of Medicinal Plants Research **5,** 1134-1139.

Johnson OR, Elizabeth MA, Oloruntoba AC, Sunday AI. 2012. Effects of Pre-induction Administration of *Allium Sativum* on Some Biochemical Parameters in Alloxan Induced Diabetic Rats Research. Journal of Applied Science, Engineering and Technology **4,** 5129-5135.

Kalejaiye O, Iwalewa E, Omobuwajo O, Oyedapo O. 2002. Hypoglycaemic effects of Nigerian *Zingiber officinale* rhizome on experimental diabetic rats. Nigerian Journal of Natural Products and Medicine **6,** 33-35.

Lau BH. 2006. Suppression of LDL oxidation by garlic compounds is a possible mechanism of cardiovascular health benefit. Journal of Nutrition **136,** 765S-768S.

Lawson LD, Wang ZJ, Papadimitriou D. 2001. Allicin release under simulated gastrointestinal conditions from garlic powder tablets employed in clinical trials on serum cholesterol. Planta Medica **67,** 13-18.

Li Y, Tran VH, Duke CC, Roufogalis BD. 2012. Gingerols of Zingiber officinale enhance glucose uptake by increasing cell surface GLUT4 in cultured L6 myotubes. Planta Medica **78,** 1549-1555.

Liu L, Yeh Y-Y. 2002. S-alk (en) yl cysteines of garlic inhibit cholesterol synthesis by deactivating HMG-CoA reductase in cultured rat hepatocytes. Journal of Nutrition **132,** 1129-1134.

Mansell P, Reckless P, Lloyd L. 1996. The effect of dried garlic powder tablets on serum lipids in non-insulin dependent diabetic patients. European Journal of Clinical Research **8,** 25-26.

Matsuura E, Hughes GR, Khamashta MA. 2008. Oxidation of LDL and its clinical implication. Autoimmunity Reviews **7,** 558-566.

McNamara J, Cohn J, Wilson P, Schaefer E. 1990. Calculated values for low-density lipoprotein cholesterol in the assessment of lipid abnormalities and coronary disease risk. Clinical Chemistry **36,** 36-42.

Milner J. 2001. Garlic: The mystical food in health promotion. In: Handbook of Nutraceuticals and Functional Foods CRC Press, Florida pp. 193-207.

Ness GC, Zhao Z, Lopez D. 1996. Inhibitors of cholesterol biosynthesis increase hepatic low-density lipoprotein receptor protein degradation Archives of Biochemistry and Biophysics **325,** 242-248.

Queiroz YS, Ishimoto EY, Bastos DH, Sampaio GR, Torres EA. 2009. Garlic (*Allium sativum* L.) and ready-to-eat garlic products: In vitro antioxidant activity. Food Chemistry **115,** 371-374.

Ramudu SK, Korivi M, Kesireddy N, Lee L-C, Cheng I-S, Kuo C-H, Kesireddy SR. 2011. Nephro-protective effects of a ginger extract on cytosolic and mitochondrial enzymes against streptozotocin (STZ)-induced diabetic complications in rats. Chinese Journal of Physiology **54,** 79-86.

Rana J, Nieuwdorp M, Jukema J, Kastelein J. 2007. Cardiovascular metabolic syndrome–an interplay of, obesity, inflammation, diabetes and coronary heart disease Diabetes, Obesity and Metabolism **9,** 218-232.

Rivlin RS. 2001. Historical perspective on the use of garlic. Journal of Nutrition **131,** 951S-954.

Robbers JE, Tyler VE. 1999. Tyler's herbs of choice. The therapeutic use of phytomedicinals. Haworth Press Inc.

Sambaiah K, Srinivasan K. 1991, Effect of cumin, cinnamon, ginger, mustard and tamarind in induced hypercholesterolemic rats. Food/Nahrung **35,** 47-51.

Sanghal A, Pant K, Natu S, Nischal A, Khattri S, Nath R. 2012. An experimental study to evaluate the preventive effect of *Zingiber officinale* (ginger) on hypertension and hyperlipidaemia and its comparison with *Allium sativum* (garlic) in rats. Journal of Medicinal Plants and Research **25,** 4231-4238.

Shinwari Z, Watanabe T, Rehman M, Youshikawa T. 2006. A pictorial guide to Medicinal Plants of Pakistan KUST Kohat Pakistan.

Sterling SJ, Eagling DR. 1997. Agronomics and allicin yield of Australian grown garlic (*Allium sativum*). In: II International Symposium on Edible Alliaceae **555,** pp. 63-73.

Stockbridge H, Hardy R, Glueck C. 1989. Photometric determination of cholesterol (CHOD-PAP method). Journal of Laboratory and Clinical Medicine **114,** 142-151.

Tapiero H, Townsend DM, Tew KD. 2004. Organ sulfur compounds from alliaceae in the prevention of human pathologies. Biomedicine and Pharmacotherapy **58,** 183-193.

Wild S, Roglic G, Green A, Sicree R, King H. 2004. Global prevalence of diabetes estimates for the year 2000 and projections for 2030. Diabetes Care **27,** 1047-1053.

Yajnik CS. 2001. The insulin resistance epidemic in India: fetal origins, later lifestyle, or both? Nutrition Reviews **59,** 1-9.

Zakir S, Sarwar M, Allen J, Butt M, Arshad U, Javaid A. 2008 Impact of sweet potato cultivars on blood glucose level in diabetic and healthy participants International Journal of Agriculture and Biology **10,** 316-320.