Original Article

Lipid-Lowering and Antioxidant Functions of Bottle Gourd (*Lagenaria siceraria*) Extract in Human Dyslipidemia

Journal of Evidence-Based Complementary & Alternative Medicine
2014, Vol. 19(2) 112-118

DOI: 10.1177/2156587214524229
cam.sagepub.com
SAGE

Charu Katare, PhD[1], Sonali Saxena, PhD[2], Supriya Agrawal, MSc[1], Anish Zacharia Joseph, PhD[2], Senthil Kumar Subramani, MSc[2], Dhananjay Yadav, PhD[2], Nita Singh, MSc[2], Prakash Singh Bisen, PhD, DSc[2], and G. B. K. S. Prasad, PhD[2]

Abstract

The study validated the antidyslipidemic, antioxidant, and antihyperglycemic effects of *Lagenaria siceraria* fruit extract in human subjects with dyslipidemia along with subjects of normal health. A total of 200 mL of freshly prepared *Lagenaria siceraria* fruit extract was administered daily on empty stomach for 90 days. Significant reductions ($P < .01$) were found in triglycerides and total cholesterol levels in blood. Cardiac risk ratio, atherogenic coefficient, and atherogenicity index of plasma were also improved. Appreciable reductions in body mass index ($P < .01$) and blood pressure (systolic $P < .01$, diastolic $P < .05$) along with a significant reduction ($P < .05$) in fasting blood glucose levels were also observed in these subjects. *Lagenaria siceraria* fruit extract exhibited significant antioxidant activity in dyslipidemic subjects as evident from elevations in SOD ($P < .05$) and GSH levels ($P < .01$) with marked improvement in catalase ($P < .01$) and TBARS levels ($P < .05$). Phytochemical screening confirmed the presence of saponins, glycosides, flavonoids, terpenoids, and phenolic compounds. *Lagenaria siceraria* fruit extract serves as dietary adjunct in treatment of human dyslipidemia and cardiovascular disease.

Keywords

Lagenaria siceraria, atherosclerosis, dyslipidemia, hyperglycemia, oxidative stress

Received August 20, 2013. Revised November 23, 2013. Accepted for publication January 13, 2014.

Introduction

Hyperlipidemia is characterized by elevation of serum lipids such as triglycerides, cholesterol, and lipoproteins. Hyperlipidemia builds up oxidative stress and may predispose the individual to many serious health conditions,[1] such as atherosclerosis, coronary artery disease, diabetes mellitus.[2] Treatment of hyperlipidemia includes chemotherapy, dietary changes, weight reduction, and exercise. Medications most commonly used to treat hypercholesterolemia and hypertriglyceridemia are statins[3] and fibrates, respectively.[4] Both the drugs, though effective, may cause side effects such as myositis (inflammation of the muscles), joint pain, stomach upset, and liver damage[5] in long run. Nutraceuticals and functional foods are gaining acceptance for their ability to address lifestyle disorders such as hyperlipidemia, metabolic syndrome, diabetes mellitus, and so on. Previous studies have shown that fresh garlic (*Allium sativum*) and garlic supplements may lower cholesterol levels, prevent blood clots, and prevent plaque formation. However, more recent studies show no effect of garlic on cholesterol, and as garlic can increase the risk of bleeding it is not advocated for those taking blood-thinning medication. *Lagenaria siceraria* (Molina) Standley fruit (bottle gourd), a commonly used vegetable in India, is traditionally considered to have cardioprotective and cardiotonic effects.[6] Different varieties of *Lagenaria siceraria* are known to exist; the sweet variety is generally used as a vegetable and for preparation of sweets and pickles, whereas the wild variety is bitter and is preferred for the medicinal use.[7] The fruits of the sweet variety are widely used in home therapies in India; drinking 1 or 2 glasses of fresh raw bottle gourd juice in the morning on an empty stomach is one such practice, particularly in India, to deal with obesity-associated disorders.[8] Over the past decade, considerable focus of the research community has been directed

[1] Department of Food & Nutrition, Kamla Raja Girls (PG), Autonomous College, Gwalior, Madhya Pradesh, India
[2] School of Studies in Biochemistry, Jiwaji University, Gwalior, Madhya Pradesh, India

Corresponding Author:
Charu Katare, PhD, Department of Food & Nutrition, Kamla Raja Girls (PG) Autonomous College, Gwalior, Madhya Pradesh 474011, India.
Email: cskatare@gmail.com

towards enhancing our understanding of functional foods as diet therapies for lifestyle-related disorders. The objective of the present study was to validate the antihyperlipidemic, antihyperglycemic, and antioxidant effects of *Lagenaria siceraria* fruit extract in human subjects with dyslipidemia and oxidative stress and normal healthy subjects.

Methods

Study Population

The subjects in the age group of 30 to 60 years attending Weekend Diabetic Clinic run by the School of Studies in Biochemistry at Jiwaji University, Gwalior, India, were screened for dyslipidemia. Twenty-five subjects with dyslipidemic condition, that is, with either elevated triglycerides (>150 mg/dL) or elevated cholesterol (>200 mg/dL) or elevated low-density lipoproteins (>130 mg/dL) based on ATP III criteria,[9] were selected for the study. Subjects with elevation of any one or more parameters were considered "dyslipidemic." Equal number of healthy subjects in the same age group served as "normolipidemic." The study design and experimental protocols were approved by the Institutional Human Ethics committee.

Exclusion Criteria

Subjects were excluded if they were on medications for any chronic disease (cancer, cardiovascular disease, diabetes mellitus, or even dyslipidemia). Persons who reported having taken lipid-lowering drugs, high-dose dietary supplements/herbal supplements, during the preceding 3 months were also excluded. Pregnant and lactating mothers were also excluded from the study.

A written consent was obtained from each participant before registering for the study. All the participating subjects were explained the health benefits of *Lagenaria siceraria* fruit extract consumption, verbally as well as with the help of paper handouts. Subjects registered for the study were asked to refrain from other herbal or nutritional supplements as they might overlap with the effect of *Lagenaria siceraria* fruit extract. Subjects were asked to maintain their usual diet, physical activity, and lifestyle while enrolled in the study.

Preparation of Lagenaria siceraria *Fruit Extract*

A sweet variety of the fruits of *Lagenaria siceraria* was used to prepare *Lagenaria siceraria* fruit extract and was purchased from a local vendor in Gwalior city, India. It was ensured that the fruits were from same source every time (same field). Fruits were examined for any infection or injury and washed thoroughly before slicing. A commercial fruit juice extractor was used for extracting juice.

Administration of Lagenaria siceraria *Fruit Extract*

A total of 200 mL of freshly prepared *Lagenaria siceraria* fruit extract was administered daily for 90 days on empty stomach to each participating subject between 7.00 and 9.00 AM during the course of the study. Daily attendance record was maintained throughout the study period. The subjects were specially instructed to discard the juice if it tasted even slightly bitter. The bitter juice is reported to contain cucurbitacins, a group of various triterpenoid substances that are identified for their bitterness and toxicity. Structurally, these are characterized by the tetracyclic cucurbitane nucleus skeleton, namely, 19-(10→9β)-abeo-10-α-lanost-5-ene (also known as 9β-methyl-19-nor lanosta-5-ene), with a variety of oxygenation functionalities at different positions. The bottle gourd fruit contains the triterpenoid cucurbitacins B, D, G, H, and 22-deoxy cucurbitacin. Higher levels of cucurbitacin are activated by environmental stress such as high temperatures, wide temperature swings, or too little water, uneven watering practices, low soil fertility, and low soil pH.[10]

Anthropometry

Body weight, height, blood pressure, and waist and hip circumference measurements were done at the time of enrolment and at monthly intervals thereafter. Systolic and diastolic blood pressure was measured in mm Hg using a sphygmomanometer. Participants were asked to sit and relax comfortably for 5 to 10 minutes before measuring blood pressure.

Blood Collection

Fasting blood samples (about 2.5 mL) were drawn in morning hours (6.30 to 8.30 AM) in glass tubes containing ethylenediaminetetraacetic acid and sodium fluoride. Plasma was separated out and stored at −20°C prior to analysis. All biochemical investigations such as glucose, triglycerides and cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol were done on fresh plasma samples. Risk factors for cardiovascular disease were also determined. Whole blood or erythrocyte lysate were used for estimation of some of the parameters of oxidative stress. All biochemical parameters were monitored once before starting the study (0th day) and at the end of the study (90th day).

Biochemical Analyses

Blood glucose was estimated by glucose oxidase-peroxidase method.[11] Plasma triglyceride was estimated by glycerol-3-phosphate oxidation-peroxidase method.[12] Total cholesterol was estimated by cholesterol-oxidase and *p*-aminophenazone method.[13] High-density lipoprotein cholesterol level was estimated by the phosphotungstate method.[14] The low-density lipoprotein and very-low-density lipoprotein levels were calculated using Friedewald's equation.[15] The atherogenic indices[16,17] are as follows: cardiac risk ratio = total cholesterol/high-density lipoprotein cholesterol; atherogenic coefficient = (total cholesterol − high-density lipoprotein cholesterol)/high-density lipoprotein cholesterol; and atherogenicity index of plasma = Log(triglycerides/high-density lipoprotein cholesterol).

Markers of Oxidative Stress

Analyses of biomarkers of oxidative stress were done using standard laboratory techniques. SOD, TBARS, and catalase activities were measured in the erythrocyte lysates using a UV-VIS Spectrophotometer. Super oxide dismutase,[18] catalase,[19] reduced glutathione,[20] and lipid peroxidation[21] were monitored once at the beginning (0th day) of the study and at the end of the study (ie, 90th day).

Chemicals

All the chemicals used in the experiments were of analytical grade; the kits and chemicals used in this experiment were purchased from E. Merck India Limited (Mumbai, India).

Table 1. Effect of *Lagenaria siceraria* Fruit Extract Administration on Fasting Blood Glucose Levels and Lipid Parameters in Human Subjects.

		Before *Lagenaria siceraria* Extract Administration		After *Lagenaria siceraria* Extract Administration for 90 Days			
Parameter	Human Subjects (n)	Mean ± SE	SD	Mean ± SE	SD	Mean % Change	*P*
Fasting blood glucose (mg/dL)	Normal (25)	92.74 ± 3.3	16.5	88.0 ± 2.5	12.7	5.07	.103
	Dyslipidemic (25)	91.98 ± 4.16	20.82	86.9 ± 3.68	18.44	5.52	.032**
Total cholesterol (mg/dL)	Normal (25)	156.8 ± 6.8	33.9	127.2 ± 4.6	22.8	18.87	.000*
	Dyslipidemic (25)	206.2 ± 5.3	26.48	158.81 ± 5.9	29.74	22.98	.000*
Triglycerides (mg/dL)	Normal (25)	110.78 ± 8.07	40.4	91.53 ± 7.8	39.0	17.38	.012**
	Dyslipidemic (25)	128.17 ± 7.2	36.27	104.6 ± 8.6	42.98	18.4	.004*
HDL-C (mg/dL)	Normal (25)	42.45 ± 2.61	13.0	42.94 ± 2.93	14.6	1.14	.816
	Dyslipidemic (25)	39.57 ± 3.05	15.27	33.64 ± 2.11	10.57	14.98	.018**
LDL-C (mg/dL)	Normal (25)	93.94 ± 6.6	33.3	73.18 ± 4.3	21.4	22.10	.006*
	Dyslipidemic (25)	145.31 ± 5.8	29.1	104.3 ± 4.8	23.98	28.25	.000*
VLDL-C (mg/dL)	Normal (25)	22.17 ± 1.62	8.08	18.50 ± 1.58	7.91	16.55	.020**
	Dyslipidemic (25)	25.63 ± 1.45	7.25	21.12 ± 1.74	8.73	17.58	.007*
Cardiac risk ratio	Normal (25)	4.08 ± 0.35	1.75	3.97 ± 0.29	1.48	2.70	.732
	Dyslipidemic (25)	5.9 ± 0.39	1.97	5.0 ± 0.22	1.14	15.01	.026**
Atherogenic coefficient	Normal (25)	3.09 ± 0.35	1.76	2.28 ± 0.23	1.16	26.21	.007*
	Dyslipidemic (25)	4.79 ± 0.40	1.98	3.97 ± 0.23	1.14	17.12	.038**
Atherogenicity index of plasma	Normal (25)	0.408 ± 0.05	0.26	0.317 ± 0.05	0.25	22.3	.026**
	Dyslipidemic (25)	0.520 ± 0.04	0.22	0.479 ± 0.05	0.26	7.91	.284

Abbreviations: HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; VLDL-C, very-low-density lipoprotein cholesterol.
**$P < .05$, *$P < .01$, as compared to 0th day values. Data were analyzed by using paired *t* test.

Feedback of the Subjects

Feedback on acceptability and the viewpoints of participating subjects were recorded at the end of the study.

Phytochemical Screening

Phytochemical analysis was done before administering the *Lagenaria siceraria* fruit extract only once as the bottle gourd was procured always from same source (field).

Sample Preparation

Lagenaria siceraria fruit extract was dried in vacuum rotatary evaporator (Roteva, India) at 35°C to 40°C to form a thick slurry, which was then lyophilized (Operon, Korea) at −55°C.

Qualitative Phytochemical Analysis

The lyophilized plant powders were subjected to qualitative phytochemical analysis by following standard analytical procedures. Detection of flavonoids was done by the Shinoda test, cardiac glycosides by the Kellar-Killani test, and terpenoids by Harbone's method.[22] Detection of saponins and phenolic compounds were analyzed by using method given in the CCRAS manual.[23]

Statistical Analysis

Results are expressed as mean ± standard deviation. And the data were analyzed by paired *t* test. The statistical analysis was carried out using SPSS (PASW statistics 17) software.

Results

Effect of Lagenaria siceraria *Fruit Extract Administration on Lipid Profile*

Serum total cholesterol triglycerides, low-density lipoprotein cholesterol, and very-low-density lipoprotein cholesterol were significantly reduced ($P < .01$) in dyslipidemic subjects with an appreciable change in normal subjects at the end of 3 months of *Lagenaria siceraria* fruit extract therapy. A reduction in high-density lipoprotein cholesterol level was observed in dyslipidemic subjects in contrast to marginal improvement in high-density lipoprotein cholesterol level in subjects with normal healthy subjects (Table 1). Cardiac risk ratio and atherogenicity coefficient were reduced ($P < .05$) in dyslipidemic subjects. Atherogenicity index of plasma was significantly reduced ($P < .05$) in normal subjects with an appreciable reduction in dyslipidemic subjects (Table 1).

Effect of Lagenaria siceraria *Fruit Extract Administration on Blood Glucose Level*

Administration of *Lagenaria siceraria* fruit extract for 3 months led to significant ($P < .05$) reduction in blood glucose levels of dyslipidemic subjects with a mean change of 5.52% (Table 1).

Effect of Lagenaria siceraria *Fruit Extract Administration on Oxidative Stress*

Significant elevations in enzymatic markers of oxidative stress were recorded in dyslipidemic subjects following *Lagenaria*

Table 2. Effect of *Lagenaria siceraria* Fruit Extract Administration on Biomarkers of Oxidative Stress in Human Subjects.

		Before *Lagenaria siceraria* Extract Administration		After *Lagenaria siceraria* Extract Administration for 90 Days			
Parameter	Human Subjects (n)	Mean ± SE	SD	Mean ± SE	SD	Mean % Change	*P*
GSH (mg/dL)	Normal (25)	2.99 ± 0.148	0.743	3.17 ± 0.10	0.55	5.68	.103
	Dyslipidemic (25)	2.46 ± 0.13	0.64	3.2 ± 0.14	0.73	23.87	.000*
SOD (units/min/mg protein)	Normal (25)	0.062 ± 0.007	0.038	0.088 ± 0.011	0.05	29.55	.086
	Dyslipidemic (25)	0.0624 ± 0.005	0.03	0.11 ± 0.015	0.08	41.13	.018**
Catalase (mmol/mine/mg protein)	Normal (25)	1.40 ± 0.44	2.18	1.93 ± 0.25	1.27	27.46	.143
	Dyslipidemic (25)	0.98 ± 0.15	0.74	1.7 ± 0.23	1.15	40.8	.000*
TBARS (nmol of MDA/mL blood)	Normal (25)	335.8 ± 32.38	161.9	297.2 ± 7.68	38.4	11.49	.289
	Dyslipidemic (25)	377.1 ± 27.11	135.6	295.5 ± 5.25	26.26	21.64	.011**

**$P < .05$, *$P < .01$, as compared to 0th day values. Data were analyzed by using paired *t* test.

Table 3. Effect of *Lagenaria siceraria* Fruit Extract on Anthropometric Parameters and Hypertension in Human Subjects.

		Before *Lagenaria siceraria* Extract Administration		After *Lagenaria siceraria* Extract Administration for 90 Days			
Parameter	Human Subjects (n)	Mean ± SE	SD	Mean ± SE	SD	Mean % Change	*P*
Body weight (kg)	Normal (25)	67.88 ± 2.06	10.31	66.24 ± 1.95	9.75	2.42	.000*
	Dyslipidemic (25)	71.95 ± 2.3	11.53	70.43 ± 2.1	10.5	2.11	.007*
Body mass index (kg/m^2)	Normal (25)	24.0 ± 0.47	2.37	23.61 ± 0.46	2.30	1.63	.002*
	Dyslipidemic (25)	27.26 ± 0.64	3.2	26.6 ± 0.55	2.72	2.43	.004*
Waist–hip ratio	Normal (25)	0.92 ± 0.01	0.05	0.87 ± 0.04	0.24	5.43	.293
	Dyslipidemic (25)	0.98 ± 0.025	0.13	0.96 ± 0.007	0.04	1.56	.512
Systolic blood pressure (mm Hg)	Normal (25)	117.6 ± 0.87	4.30	115.8 ± 0.98	4.90	1.53	.026**
	Dyslipidemic (25)	127 ± 1.43	7.13	123 ± 0.83	4.18	3.15	.006*
Diastolic blood pressure (mm Hg)	Normal (25)	78.4 ± 1.1	5.5	77.2 ± 0.91	4.6	1.53	.327
	Dyslipidemic (25)	82.4 ± 1.23	6.15	79.5 ± 0.70	3.51	3.52	.031**

**$P < .05$, *$P < .01$, as compared to 0th day values. Data were analyzed by using paired *t* test.

siceraria fruit extract administration for 3 months. A marked improvement of antioxidants, viz, GSH, catalase ($P < .01$), SOD ($P < .05$), was recorded in dyslipidemic subjects. There was also marked improvement in antioxidant status of normal healthy subjects, though not to a statistically significant level. TBARS level was significantly reduced ($P < .05$) in dyslipidemic subjects (Table 2).

Effect of Lagenaria siceraria *Fruit Extract Administration on Body Weight and Blood Pressure*

There was reduction in body weight and body mass index of the subjects in normal health and dyslipidemic subjects. Significant decrease ($P < .01$) in body mass index was observed in the dyslipidemic group (mean difference 2.43%) as well as in the normal healthy subjects (mean difference 1.63%) at the end of *Lagenaria siceraria* fruit extract therapy. Waist–hip ratio remained unchanged in both the groups. A significant fall ($P < .01$) in systolic as well as diastolic blood pressures ($P < .05$) was observed in dyslipidemic subjects, whereas a significant decrease ($P < .05$) in systolic blood pressure and a marginal decrease (mean change 1.53%) in diastolic blood pressure of normal subjects following *Lagenaria siceraria* fruit extract therapy was noticed (Table 3).

Phytochemical Screening of Lagenaria Siceraria

Phytochemical analysis of *Lagenaria siceraria* fruit extract indicated the presence of saponins, flavonoids, cardiac glycosides, terpenoids, and phenolic compounds (Table 4).

Discussion

Lowering of blood lipid levels reduces the risk of heart disease and stroke. The present study validated systematically the antihyperlipidemic, antihyperglycemic, and antioxidant functions of freshly prepared fruit extract of *Lagenaria siceraria* in human subjects with dyslipidemia and hyperglycemia. Daily oral administration of *Lagenaria siceraria* fruit extract for over

Table 4. Qualitative Phytochemical Analysis of *Lagenaria siceraria* Fruit Extract.

Phytochemicals	*Lagenaria siceraria* Juice Extract
Saponins	+
Tannins	−
Alkaloids	−
Flavonoids	+
Cardiac glycosides	+
Triterpenoids	+
Phenolic content	+

a period of 3 months to dyslipidemic subjects resulted in significant reductions in total cholesterol, triglycerides, low-density lipoprotein cholesterol, and very-low-density lipoprotein cholesterol and fasting blood glucose levels (Table 1). A phytochemical and pharmacological review of *Lagenaria siceraria* reports that 4 different extracts, viz, petroleum ether, chloroform, alcoholic, and aqueous extracts, were prepared. Oral administration of the extracts to triton induced hyperlipidemic rats dose-dependently inhibited the total cholesterol, triglycerides, and low-density lipoproteins levels and significantly increased the high-density lipoproteins level.[24] Phytoconstituent screening of *Lagenaria siceraria* fruit extract revealed the presence of saponins and flavonoids. Saponin binds with cholesterol in intestinal lumen affecting its absorption, and saponin also increases lipoprotein lipase activity.[25] Flavonoids regulate blood lipids by enhancing activity of lecithin acyl transferase, which plays a key role in the incorporation of free cholesterol into high-density lipoprotein and transferring it back to very-low-density lipoprotein and low-density lipoprotein, which are taken back later in liver cells.[26] Besides phytoconstituents, *Lagenaria siceraria* fruit extract contains more proportion of soluble dietary fibers than insoluble fibers. Soluble dietary fibers have a profound effect in lowering serum cholesterol, which also reveals that the pectin is a predominant component of soluble fibers in *Lagenaria siceraria* fruits.[27] Atherogenic indices are powerful indicators of the risk of heart disease: the higher the value, the higher the risk of developing cardiovascular disease and vice versa.[16,17,28] In this study, it was observed that the extract reduced atherogenic indices cardiac risk ratio and atherogenicity coefficient. Low atherogenic indices are protective against coronary heart disease.[28]

Oxidative stress is known to be associated with all lifestyle disorders including coronary heart diseases.[29] The study confirmed that regular consumption of freshly prepared aqueous extract of bottle gourd fruit results in marked improvement in biomarkers of oxidative stress. Our observations on antioxidant potential of *Lagenaria siceraria* fruit extract corroborates with the observation of earlier worker.[6] Oxidation of low-density lipoprotein is a risk factor and plays an important role in development of atherosclerosis. A decrease in oxidative stress and protection of low-density lipoprotein from oxidation might therefore be a strategy with great promise for prevention of atherosclerosis-associated cardiovascular disease.[30] Free radicals have been shown to be harmful as they react with important cellular components such as proteins, DNA, and cell membrane.[31] Administration of *Lagenaria siceraria* fruit extract improved the biochemical marker levels as evident from increased blood levels of GSH, SOD, and catalase with concomitant decrease in lipid peroxidation (Table 2).

The flavonoids present in fruit extract of *Lagenaria siceraria* possess free radical–scavenging ability. The ingested flavonoids are extensively degraded to various phenolic acids, some of which still possess a radical-scavenging ability. Both the absorbed flavonoids and their metabolites exhibit antioxidant activity in vivo.[32]

Glycosides are an important class of bioactive compounds responsible for the specific medicinal values that are present in various medicinal plants like digitalis, liquorices, and such other pants. The glycoside molecules contain a sugar that is bound to a noncarbohydrate moiety, which play numerous important roles in living organisms; many plants store chemicals in the form of inactive glycosides and these can be activated by enzyme hydrolysis.[33]

Hypertension is one of the risk factors for angina and myocardial infarction. Control of blood pressure is advocated in patients with angina. In the current study, *Lagenaria siceraria* fruit extract administration brought a significant decline ($P < .05$) in systolic and diastolic blood pressure in dyslipidemic subjects (Table 3). Aqueous soluble extract of *Lagenaria siceraria* has been reported to increase urine volume.[34] The diuretic activity of *Lagenaria siceraria* has been attributed to ion content. Diuretics are known antihypertensive agents. It is reported that long-term treatment (51 days) of *Lagenaria siceraria* fruit powder (500 mg/kg) partially reversed dexamethasone-induced hypertension in rats.[35]

None of the dyslipidemic subjects in the study were on lipid-lowering medication and also no significant dietary and lifestyle changes in participating subjects were noted during the course of study. The present study, which is one of the pioneering studies administering fresh *Lagenaria siceraria* fruit extract under personal supervision to dyslipidemic human subjects continuously for 90 days, confirmed the antihyperlipidemic, antihypertensive, and antioxidant functions of fresh *Lagenaria siceraria* fruit extract. The *Lagenaria siceraria* fruit extract may be used as potent adjunct therapy in human hyperlipidemia and possibly also in cardiovascular disorders. The active principles associated with lipid-lowering functions and their cellular targets in human subjects needs further investigations.

Conclusion

The *Lagenaria siceraria* fruit extract can serve as a powerful Nutraceutical with significant lipid-lowering and antioxidant functions and may find useful as a prophylactic measure for subjects with cardiovascular risk. This study confirmed that regular intake of *Lagenaria siceraria* fruit extract reduces atherogenic indices, viz, cardiac risk ratio and atherogenicity coefficient and oxidative stress, and may be of therapeutic use in addressing lifestyle disorders.

Acknowledgments

The financial support extended by University Grants Commission, New Delhi, in the form of a major research project is duly acknowledged. The authors are thankful to the research staff for their assistance and support in conducting this study. The authors sincerely thank all the subjects who participated in the study with enthusiasm and for following the guidelines sincerely.

Author Contributions

SS, SA, AZJ, SKS, DY, and NS were involved in the experimental work, registration, follow-up, collection of blood specimens, and supervision of the bottle gourd juice administered. CK, PSB, and GBKSP were associated with the study design, execution, and preparation of the article.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship and/or publication of this article: The study was funded by the University Grants Commission, New Delhi, India (UGC Letter No. F-34-116/2008(SR), dated December 29, 2008).

Ethical Approval

The study design and experimental protocols were approved by the Institutional Human Ethics Committee.

References

1. Durrington P. Dyslipidemia. *Lancet*. 2003;362:717-731.
2. Hunt JV, Smith CC, Wolff SP. Autoxidation glycosylation and possible involvement of peroxides and free radicals in LDL modification by glucose. *Diabetes*. 1990;39:1420-1424.
3. Henry N, Ginsberg MD. Effects of statins on triglyceride metabolism. *Am J Cardiol*. 1998;81(4):32B-35B.
4. Brunzell JD. Familial lipoprotein lipase deficiency and other causes of the chylomicronemia syndrome: In: Scriver CR, Beaudet AL, Sly WS, Valle D, eds. *The Metabolic and Molecular Bases of Inherited Disease*. 7th ed. New York: PMcGraw-Hill; 1995: 1913-1932.
5. Kolovou GD, Kostakou PM, Anagnostopoulou KK, Cokkinos DV. Therapeutic effects of fibrates in postprandial lipemia. *Am J Cardiovasc Drugs*. 2008;8:243-255.
6. Deshpande JR, Choudhari AA, Mishra MR, Meghre VS, Wadodkar SG, Dorale AL. Beneficial effect of *Lagenariasiceraria* (Mol.) Standly fruit epicarp in animal models. *Indian J Exp Biol*. 2008; 46:234-242.
7. Sivarajan SS, Balchandra A. *Ayurvedic Drugs and Their Plant Source*. New Delhi, India: IBH Publication Company; 1994: 176-177.
8. Shirwaikar A, Sreenivasan KK. Chemical investigation and antihepatotoxic activity of the fruit of *Lagenaria siceraria*. *Indian J Pharm Sci*. 1996;58:197.
9. National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). Third report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation*. 2002;106:3143-3421.
10. Sharma SK, Puri R, Jain A, et al. Assessment of effects on health due to consumption of bitter bottle gourd (*Lagenaria siceraria*) juice. *Indian J Med Res*. 2012;135:49-55.
11. Raobdo E, Terkildsen TC. On the enzymatic determination of blood glucose. *Scand J Clin Lab Invest*. 1960;12:402-407.
12. Fossati P, Prencipe L. Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. *Clin Chem*. 1982;28:2077-2080.
13. Stockbrige H, Glueck J. Public cholesterol screening: motivation for participation, follow-up outcome, self-knowledge and coronary heart disease risk factor intervention. *J Lab Clin Med*. 1989; 114:142-151.
14. Lopes-Virella MF, Stone P, Ellis S, Colwell JA. Cholesterol determination in high-density lipoproteins separated by three different methods. *Clin Chem*. 1977;23:882-883.
15. Friedewald WT, Levy RI, Friedrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem*. 1972; 18:499-502.
16. Brehm A, Pfeiler G, Pacini G, Vierhapper H, Roden M. Relationship between serum lipoprotein ratios and insulin resistance in obesity. *Clin Chem*. 2004;50:2316-2322.
17. Frohlich J, Dobiásová M. Fractional esterification rate of cholesterol and ratio of triglycerides to HDL-cholesterol are powerful predictors of positive findings on coronary angiography. *Clin Chem*. 2003;49:1873-1880.
18. Winterbourn CC, Hawkins RE, Brian M, Carrell RW. Estimation of red cell superoxide dismutase activity. *J Lab Clin Med*. 1975; 85:337-341.
19. Sinha AK. Colorimetric assay of catalase. *Anal Biochem*. 1972; 47:389-394.
20. Ellman GL. Tissue sulfhydryl groups. *Arch Biochem*. 1959;82: 70-77.
21. Ohkawa H, Ohishi N, Yagi K. Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. *Anal Biochem*. 1979;95: 351-358.
22. Harbone JB. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. London, England: Chapman & Hall; 1998.
23. Central Council for Research in Ayurveda and Siddha. *Laboratory Guide for the Analysis of Ayurveda and Siddha Formulations*. New Delhi, India: Department of AYUSH, Ministry of Health and Family Welfare, Government of India; 1997:81-87.
24. Prajapati RP, Kalariya M, Parmar SK, Sheth NR. Phytochemical and pharmacological review of *Lagenaria sicereria*. *J Ayurveda Integr Med*. 2010;1:266-272.
25. Fukushima M, Matsuda T, Yamagishi K, Nakano M. Comparative hypocholesterolemic effects of six dietary oils in cholesterol-fed rats after long-term feeding. *Lipids*. 1997;32:1069-1074.
26. Sharma DK. Hypolipidemic effect of different extracts of *Clerodendron colebrookianum* Walp in normal and high-fat diet fed rats. *J Ethnopharmacol*. 2004;90:63-68.

27. Milind P, Kaur S. Is bottle gourd a natural guard? *Int Res J Pharm*. 2011;2(6):13-17.
28. Usoro IN, Nsonwu AC. Lipid profile of postmenopausal women in Calabar, Nigeria. *Pak J Nutr*. 2006;5:79-82.
29. Erasto P, Mbwambo ZH. Antioxidant activity and HPTLC profile of *Lagenaria siceraria* fruits. *Tanzania J Health Res*. 2009;11(2): 79-83.
30. Steinberg D, Gotto AM. Preventing coronary artery disease by lowering cholesterol levels: fifty years from bench to bedside. *JAMA*. 1999;282:2043-2050.
31. Mantena SK, King AL, Andringa KK, Eccleston HB, Bailey SM. Mitochondrial dysfunction and oxidative stress in the pathogenesis of alcohol and obesity-induced fatty liver diseases. *Free Radic Biol Med*. 2008;44:1259-1272.
32. Pier GP. Flavonoids as antioxidants. *J Nat Prod*. 2000;63: 1035-1042.
33. Joy PP, Thomas J, Mathew S, Skaria BP. *Medicinal Plants: Tropical Horticulture*. Calcutta, India: Naya ProKash; 2001:449-632.
34. Ghule BV, Ghante MH, Yeole PG, Saoji AN. Diuretic activity of *Lagenaria siceraria* fruit extract in rats. *Indian J Pharm Sci*. 2007;69:817-819.
35. Mali VR, Bodhankar SL. Effect of *Lagenaria siceraria* (LS) powder on dexamethasone induced hypertension in rats. *Int J Adv Pharm Sci*. 2010;1:50-53.