Antioxidant and 3-hydroxy-3-methylglutaryl Coenzyme A reductase inhibitory activities of some plant samples

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ABSTRACT

The antioxidant activity capacities of some plants, and their inhibitory effects on the HMG-CoA reductase enzyme, the rate-determining enzyme of cholesterol synthesis, were investigated in our study. Antioxidant activity capacity and inhibitory effect of the HMG-CoA reductase enzyme were detected in all plant extracts used in our research. From the results obtained, it was determined that both antioxidant activity and % inhibition values of HMG-CoA reductase enzyme increased as the plant extracts concentration increased. The strongest ABTS and DPPH radical scavenging activities were exhibited by pomegranate fruit extract (IC₅₀ = 1.07 ±0.04 mg/mL and IC₅₀ = 0.39 ±0.01 mg/mL, respectively). At the same time, lemon had the strongest DMPD radical scavenging activity (IC₅₀ = 9×10⁻⁴ ±6×10⁻⁵ mg/mL). The best HMG-CoA reductase inhibitory activity was observed in persimmon fruit extract (IC₅₀ = 0.71 ±0.18 µg/mL). The inhibitory power of this extract was much higher than that of the enzyme’s standard inhibitor, Atorvastatin (IC₅₀ = 1.76 ±0.12 µg/mL). The extracts’ potent antioxidant and inhibitory properties can be attributed to the rich phytochemical composition of plant extracts. Thus, it may be a potential source of new bioactive compounds effective against oxidative stress, hypercholesterolemia and cardiovascular complications.

Keywords: Antioxidant activity, Enzyme, HMG-CoA reductase, Inhibition, Plants
Introduction

Free radicals are metabolic by-products continuously produced via normal metabolic processes of the biological system. These molecules are highly reactive and unstable, thus detrimental to organisms’ general well-being. In humans, the excessive production of these molecules, coupled with compromised antioxidant-oxidant balance, present severe health challenges such as cardiovascular dysfunction, premature ageing, neurological disorders and mutagenesis (Aruoma, 1994; Bagchi and Puri, 1998; Floyd, 1999; Njie-Mbye et al., 2013) these lead modification and destruction of biologically important macromolecules such as lipids, proteins, DNA and carbohydrates. The biological system is armed with an antioxidant defence mechanism that helps eliminate the toxic effect of free radicals. This antioxidant defence system involves the activity of antioxidant enzymes (i.e., superoxide dismutase, catalase, glutathione peroxidase and glutathione reductase) that works synergistically with the non-enzymatic antioxidant systems that include vitamins (vitamin A, C and E), antioxidant minerals (i.e. copper, zinc and selenium), appropriate biological levels of uric acid and bilirubin, plant-based antioxidants (such as polyphenols) etc. Some of these antioxidant molecules can unilaterally capture or detoxify free radicals, thus essential for healthy living.

Cholesterol is a lipid synthesised by all animal cells via the mevalonate pathway (Brown and Goldstein, 1997; Espenshade and Hughes, 2007). It is an indispensable component of the cell membrane and an important precursor of steroid hormones, bile and vitamin D (Yeagle, 1991; Hanukoglu, 1992; Haines, 2001; Payne and Hales, 2004). Despite the biological significance of cholesterol, its elevated level in human blood has health consequences such as the increased risk of atherosclerosis, heart attack, stroke, and peripheral artery disease (Lewington et al., 2007; Brunzell et al., 2008). Various studies have shown that lowering blood cholesterol levels can reduce the risk of coronary heart disease, regress existing atherosclerotic lesions in peripheral arteries, and reduce the risk of stroke risk and cardiovascular disease (Grundy et al., 2019). Thus, regulating both intake and biosynthesis of cholesterol is essential for normal well-being. The regulation of cholesterol levels in patients usually involves the use of statins. These group of compounds are known to be excellent inhibitors of hydroxy methylglutaryl-CoA (HMG-CoA) reductase (an important enzyme of the mevalonate pathway), thereby having the ability to slow down the biosynthesis of mevalonate and accumulation of cholesterol, and its accompanying defects (Nicholls, 2008; Kizer et al., 2010). Despite the proven effects of HMG-CoA reductase in reducing blood cholesterol levels and risk cardiovascular disease, they are suggested to cause liver damage, neuropathy, pancreatic dysfunction, muscle pain/damage, bleeding stroke, an increased risk of diabetes mellitus and sexual dysfunction (Golomb and Evans, 2008; Bellosta and Corsini, 2012; Naci et al., 2013; Collins et al., 2016; Lehrer and Rheinstein, 2020). Therefore, finding alternative food-based sources capable of HMG-CoA reductase inhibition is of medical significance.

Plants are outstanding sources of phytoactive compounds, thus, exhibit remarkable antioxidant activities (Magaji et al., 2022). Reports have shown that flavonoids and polyphenols can prevent the oxidation of haemoglobin to methaemoglobin through the scavenging of nitrites, thereby preventing anemia (Frei et al., 1988; Choi et al., 1988; Kang et al., 1996). Moreover, plant-based chemicals such as carotenoids, flavonoids, glycosides, polyphenols, saponins, and terpenes act as inhibitors of enzymes while also exhibiting regenerative, wound healing, anti-inflammatory, and antitumor activity. A diet rich in these phytochemicals positively correlates with lower degenerative and pathological diseases and improved well-being (Willcox et al., 2004; Mahato and Sharma, 2019). In the present study, the antioxidant activity and HMG-CoA reductase inhibitory effects of 80% ethyl alcohol extract of some plant extracts were investigated.

Materials and Methods

Plant Samples

Quince (Cydenia vulgaris), apple (Malus domestica), grapefruit (Citrus paradise), lemon (Citrus limon), pomegranate (Punica granatum), persimmon (Diospyros kaki), radish (Raphanus sativus) and onion (Allium cepa) were bought from local market, washed and rinsed with distilled water, then dried in the shade. Individual extracts were prepared with 80% ethyl alcohol using the dried plant parts.

Preparation of Ethyl Alcohol Extracts

Five grams of the dried plant sample was placed in a 250 mL Erlenmeyer flask containing 50 mL of 80% ethyl alcohol; the flask was closed with a parafilm. The mixture was stirred continuously in a dark cupboard at room temperature for 7 days. The solvent used for extraction was removed from the resulting filtrate under reduced pressure using a rotary evaporator. The amount of extract obtained was weighed and recorded.
ABTS Radical Scavenging Activity

2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging activity was performed according to the method of Arnao et al. (2001). ABTS was dissolved in distilled water to make a 7.4 mM, adding 1 mL of 2.6 mM potassium persulfate. The solution was kept away from light at room temperature for 12 to 16 hours. To 1 mL of the resulting solution, 60 mL of methyl alcohol was added to obtain the freshly prepared ABTS radical cation solution required for each experiment. Plant extracts (150 µL) were added to 2850 µL of ABTS radical cation, then kept in the dark for 2 hours before taking absorbance reading at a wavelength of 734 nm. Butylated hydroxyanisole (BHA) was used as a standard ABTS radical scavenger. % ABTS radical scavenging activity was calculated as follows:

\[
\text{ABTS radical scavenging activity (\%)} = \left(\frac{A_0 - A_1}{A_0}\right) \times 100
\]

A0: Control absorbance value.
A1: Absorbance value of sample and standard.

DMPD Radical Scavenging Activity

The basis of DMPD radical scavenging activity is that in acidic pH, DMPD forms a stable-coloured radical cation in a suitable oxidant solution. The DMPD extreme shows a maximum absorbance value of 505 nm. Antioxidants that transfer H atoms to the DMPD extreme lead to decolourising the radical solution.

\[
\text{DMPD (colourless)} + \text{Oxidant (Fe}^{3+}\text{)} + \text{H}^+ \rightarrow \text{DMPD}^+ \text{(purple)} \\
\text{DMPD}^+ \text{(purple)} + \text{AOH} \rightarrow \text{DMPD}^+ \text{(colourless)} + \text{AO}
\]

DMPD radical scavenging activity was performed according to the method of Fogliano et al. (1999). A 209 mg DMPD radical was dissolved in 10 mL of bidistilled water. A 1 mL of this solution was taken and added to 100 mL of Na-acetate buffer (0.1 M, pH: 5.3). A coloured DMPD radical cation was obtained by adding 0.2 mL of 0.05 M FeCl3 to the solution. In the radical scavenging assay, 1 mL of the radical solution was added to 0.5 mL of extract solutions. After 10 minutes, absorbance was taken using a spectrophotometer at 505 nm against the buffer solution. Epicatechin was used as a standard DMPD radical scavenger. % DMPD radical scavenging activity was calculated as follows:

\[
\text{DPPH radical scavenging activity (\%)} = \left(\frac{A_0 - A_1}{A_0}\right) \times 100
\]

A0: DMPD initial absorbance
A1: Absorbance of the sample

DPPH Radical Scavenging Activity

1,1'-diphenyl-2-picrylhydrazil (DPPH) radical scavenging activity was determined according to the method developed by Brand-Williams et al. (1995). A 20 mg/L solution of DPPH in methyl alcohol was prepared daily. To 1.5 mL of the DPPH solution, 0.75 mL of various concentrations of plant extracts (0.001–5 mg/mL) were added. The absorbance value was read after 5 minutes against the blank at 517 nm using a spectrophotometer. A 0.75 mL methyl alcohol and 1.5 mL DPPH solution were used as control. Rutin (0.0001-1.0 mg/mL) was used as a standard percentage of DPPH radical scavenging activity and was calculated using the following formula:

\[
\text{Percentage DPPH radical scavenging activity (\%)} = \left(\frac{A_0 - A_1}{A_0}\right) \times 100
\]

A0: Absorbance of control
A1: Absorbance of sample and standard material

HMG-CoA Reductase Inhibition Assay

The inhibitory activity of the HMG-CoA reductase was assayed using the procedure outlined in the CS1090 kit of Sigma Aldrich. Briefly, 910 μL of buffer was placed into a test tube and added 5 μL of the inhibitors (0.01-10.00 μg/mL). The solutions were thoroughly mixed before adding 20 μL of NADPH, and 60 μL of HMG-CoA, then allowed to stand for 5 minutes at room temperature. After that, 5 μL of HMG-CoA reductase was added to the mixture, gently mixed, and allowed to stand for another 5 minutes. The absorbance of samples was read spectrophotometrically at 340 nm against corresponding reagent blanks. Atorvastatin was used as the standard inhibitor of HMG-CoA reductase.

Percentage enzyme inhibition was calculated as follows:

\[
\% \text{Inhibition} = \left(\frac{A_0 - A_1}{A_0}\right) \times 100
\]

A0: Absorbance of control
A1: Absorbance of sample and standard material

For enzyme inhibitor activities, the results are given as half maximal inhibitory concentrations (IC50 values) calculated regression prepared from the concentrations of samples. Using regression analysis data, half maximum inhibition/scavenging concentration (IC50) was calculated from enzyme inhibition % activities and antioxidant activities % (for ABTS, DMPD, and DPPH radical scavenging). Lower IC50 values
indicate higher inhibitory potential and antioxidant activities of the tested plant extract.

Results and Discussion

Plants are natural sources of biologically active compounds (such as vitamins and polyphenols) with diverse biochemical and therapeutic activities (Proteggente et al., 2002; Rufino et al., 2010; Rinaldo et al., 2014; Afam et al., 2021). Among the therapeutic benefit of fruits and vegetables is their strong antioxidant activities (Wang et al., 1996; Karadeniz et al., 2005; Almeida et al., 2011; Dandare et al., 2017; Magaji et al., 2022). Quince has been reported to contain high levels of ascobic acid (Gheisari and Abhari, 2014; Mir et al., 2016). Phytochemical analysis reveals that apples contain the appreciable level of vitamin C, phenols and flavonoids (that include anthocyanins, catechin, chlorogenic acid, hydroxycinnamic acids, phloridzin, procyanidins and quercetin) (Siqueira et al. 2013; Djenidi et al., 2020; Asale et al., 2021; Vasile et al., 2021). Citrus, including grapefruit and lemon, were reported to be exclusively rich in vitamin C and α-tocopherol, in addition to phytochemicals like flavonoids, condensed tannins, limonoids, gallic acid, protocatechuic acid, p-hydroxybenzoic acid, vanillic acid, caffeic acid, p-coumaric acid, salicylic acid, ferulic acid, anisic acid, triterpenes and sinapic acid (Garcia-Closas et al., 2004; Gorinstein et al., 2018; Alrasheid et al., 2019; Djenidi et al., 2020). In different varieties of pomegranate, phenolic compounds (ellagic acid, gallic acid, chlorogenic acid, caffeic acid, vanillic acid, ferulic acids trans-2-hydrocinnamic acid, quercetin) and flavones (catechin, rutin, quercetin and phloridzin) were identified (Hmid et al., 2017; Djenidi et al., 2020; Tekin and Kucukbay et al., 2020). Phytochemical analysis by Lee et al. (2012), Murathan (2020) and Aydin (2021) reported the presence of tartaric acid, malic acid, lactic acid, citric acid, catechins, phenols, flavonoids and ascorbic acid in persimmon fruit. Radish fruits are rich in flavonoids (such as myricetin, catechin, epicatechin, and quercetin), phenols (e.g. quercetin, o-coumaric acid, tyrosol, sinapic acid, vanillic acid, vinyl guaiacol), glycosides, terpenes and fatty acids (Beevi et al., 2010; Xiao et al., 2012; Baenas et al., 2014; Goyeneche et al., 2015; Park et al., 2016; Selyutina and Gapontseva, 2016; Chihoub et al., 2019). Onion, on the other hand, contains high levels of organosulfur and phenolic compounds such as onions, cycloalliin, isoalliin, methin, quercetin and rutin (Alagarsamy et al., 2018; Zhao et al., 2021). These phytochemicals are responsible for fruits and vegetables' antioxidant activities and therapeutic benefits.

The antioxidant activities of plants investigated in the present study are presented in Table 1. Persimmon and quince exhibited minor ABTS radical scavenging activity (with IC50 values of 17.80 ±1.12 and 9.47 ±0.83 mg/mL, respectively), while apple IC50 = 6.32 ±0.09 mg/mL, lemon (IC50= 4.96 ±0.20 mg/mL), onion (IC50= 3.73 ±0.08 mg/mL), grapefruit (IC50= 3.63 ±0.11 mg/mL) and radish (IC50= 2.90 ±0.05 mg/mL) had moderate ABTS radical scavenging activity. The strongest ABTS radical scavenging action was exhibited by pomegranate (IC50= 1.07 ±0.04 mg/mL). The ABTS radical scavenging activities of the plants above were far below that of BHA (IC50= 0.07 ±3.0×10⁻³), used as a standard. Analysis of DMPD radical scavenging activity revealed that lemon had the strongest DMPD radical scavenging activity (IC50= 9×10⁻⁴ ±6×10⁻⁵ mg/mL), followed by grapefruit, onion and pomegranate respectively (IC50= 0.04 ±1×10⁻³, 0.06 ±6×10⁻³, 0.08 ±6×10⁻⁴ mg/mL). The minor scavenging activities were found in quince (IC50= 1.15 ±0.03 mg/mL), apple (IC50= 1.20 ±0.06 mg/mL), radish (IC50 = 1.25 ±0.04 mg/mL) and persimmon (IC50= 1.70 ±0.02 mg/mL). Despite the excellent DMPD radical scavenging activity exhibited by lemon in the present study, its action was still below that of the standard used, i.e. epicatechin (IC50= 6.6×10⁻⁵ ±4.8×10⁻⁵ mg/mL). As observed in the present study, pomegranate (IC50 = 0.39 ±0.01 mg/mL) and grapefruit (IC50 = 0.99 ±0.05 mg/mL) exhibited strong DPPH radical scavenging activities, though not beyond that of rutin (IC50= 0.24 ±0.01 mg/mL) which used as standard. Lemon, apple, onion, persimmon, and radish (IC50 values of 1.97 ±0.08, 2.24 ±0.15, 2.45 ±0.17, 3.42 ±0.42, 4.74 ±0.04 mg/mL, respectively) had moderate scavenging activities, while quince (IC50= 9.02 ±0.17 mg/mL) had the minor scavenging activity.

The outcomes of the present finding agree with previous reports that indicated antioxidant and free radical scavenging activity of reported quince, apple, grapefruit, lemon, pomegranate, persimmon, radish and onion. Quince has been shown to contain high levels of phytochemicals. The fruit exhibit promising antioxidant activity such as reducing power, ferric reducing antioxidant power (FRAP) and DPPH radical scavenging activity in the range of 70.9-89.5%, 1.40-1.68 µM and 79.91-82.61%, respectively (Mir et al., 2016). Similarly, Muzykiewicz et al. (2018) reported that ripe and unripe quince fruit have DPPH, FRAP, and ABTS radical scavenging activity. At 60 minutes extraction time, 70% ethanol of the unripe fruit had DPPH and ABTS radical scavenging activity of 29.43 ±0.31 % and 9.10±0.16 %, respectively, as against 15.78 ±0.59 % and 7.19±0.44 % of the ripe fruit. DPPH radical scavenging activity of the unripe and ripe fruits are 1.51 and 0.81 mg Trolox/g, respectively. Asale et al. (2021) reported that apple juice had DPPH radical scavenging...
activity and iron-reducing power of up to 86.20 ± 2.28 µg/mL 
and 1.93 ± 0.66 mg/mL, respectively. The highest total anti-
oxidant activity observed was 0.46 ± 0.08 mg BHT equivalent/g. 
More so, a study by Siqueira et al. (2013) have shown 
that apple has both strong DPPH radical and ferric-reducing 
antioxidant power (FRAP), thus exhibiting excellent antiradi-
cal effects.

Citruses such as grapes and lemons are rich in ascorbic acid 
(Makni et al., 2018; Alrasheid et al., 2019) and thus are ex-
cellent antioxidant sources. Studies have shown that grape-
fruit had both DPPH and ABTS radical scavenging activity. 
Depending on the variety, DPPH scavenging activity ranged 
from 35.25 ± 0.15% to 46.08 ± 0.10%, while ABTS radical 
scavenging activity was between 61 ± 0.06% to 0.92 ± 0.08 
(Sicari et al., 2018). In another study by Agudelo et al. (2017), 
grapes exhibited a DPPH scavenging activity ranging from 
5.61 ± 0.07 to 8.61 ± 0.10 mg/mL, while the ferric reducing 
power of the fruit was between 1.67 ± 0.01 to 3.10 ± 0.30 
mg/mL. The highest lipid peroxidation inhibi
[271x477]tion as β
[271x477]–caro-
tetene bleaching and TBARS formation inhibition are 19.2
± 0.70 µg/mL and 4.17 ± 0.06 µg/mL (Agudelo et al., 2017).

Conversely, Lemon had a DPPH radical quenching ability of
IC50= 434.50 ± 5.9 µg/mL and a reducing power of around 0.15 µg/mL (Makni et al., 2018). A report by Oikeh et al. (2015) 
showed that Grape and lemon juice have DPPH scavenging 
activity (24.0 ± 0.10 and 5.25 ± 0.40 mg/mL, respectively) and 
FRAP 364.2 ± 10.25 and 122.75 ± 3.25 μmol/L Fe(II)/g re-
spectively). Ripe fruit of pomegranate has been shown to
have antioxidant activities by a testing method such as DPPH radical scavenging activity, ABTS scavenging activity and 
FRAP of 319.2 ± 4.2, 778.8 ± 2.4 and 525.3 ± 15.8 μmol 
Trolox/g dry mass, respectively (Magangana et al., 2021).

Comparative antioxidant analysis between astringent, non-
astringent and wild types of persimmons by Aydin (2021) in-
dicated that the wild type had higher antioxidant potential 
than the other types. The ABTS, CUPRAC, DPPH, and 
FRAP activities were 112.95 ± 1.48, 550.24 ± 1.30, 232.56 ± 
3.08 and 542.69 ± 1.84 μmol Trolox/g, respectively. Re-
search into the antioxidant potentials of radishes revealed that 
some varieties of the fruit could have superoxide radical scav-
enging activity of up to 68.87% at 1000 µg/mL and a DPPH activity of about 20.78% (Park et al., 2016). Onion is an es-
ential source of bioactive and antioxidant compounds as a 
vegetable. The antioxidant activities of this vegetable are re-
ported not to be drastically influenced by heating or cooking 
(Moreno-Ortega et al., 2020). FRAP and DPPH radical scav-
enging activities were 12.40 ± 0.12 mg Trolox/g dry mass and 
8.00 ± 0.23 mg Trolox/g dry mass before heating. After heat-
ing for 10 minutes at 80°C, the FRAP and DPPH radical scav-
enging activities were reduced to 10.57 ± 0.34 and 6.50 ± 0.37 
mg Trolox/g dry mass (Ren et al., 2017).

In general, the antioxidant activities exhibited by fruits and 
the vegetable investigated in the present study can be at-
tributed to the phytochemical component such as ascorbic acid, tocopherol, quercetin, and rutin, among other vitamins 
and polyphenols present in the plant extracts.

Table 1: Antioxidant activities of ethyl alcohol extracts from various plants.

<table>
<thead>
<tr>
<th>Plant/Standard Inhibitor</th>
<th>ABTS (IC50; mg/mL)*</th>
<th>DMPD (IC50; mg/mL)*</th>
<th>DPPH (IC50; mg/mL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quince</td>
<td>9.47 ± 0.83</td>
<td>1.15 ± 0.03</td>
<td>9.02 ± 0.17</td>
</tr>
<tr>
<td>Apple</td>
<td>6.32 ± 0.09</td>
<td>1.20 ± 0.06</td>
<td>2.24 ± 0.15</td>
</tr>
<tr>
<td>Grapefruit</td>
<td>3.63 ± 0.11</td>
<td>0.04 ± 1x10^-3</td>
<td>0.99 ± 0.05</td>
</tr>
<tr>
<td>Lemon</td>
<td>4.96 ± 0.20</td>
<td>9x10^-4 ± 6x10^-5</td>
<td>1.97 ± 0.08</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>1.07 ± 0.04</td>
<td>0.08 ± 6x10^-3</td>
<td>0.39 ± 0.01</td>
</tr>
<tr>
<td>Persimmon</td>
<td>17.80 ± 1.12</td>
<td>1.70 ± 0.02</td>
<td>3.42 ± 0.42</td>
</tr>
<tr>
<td>Radish</td>
<td>2.90 ± 0.05</td>
<td>1.25 ± 0.04</td>
<td>4.74 ± 0.04</td>
</tr>
<tr>
<td>Onion</td>
<td>3.73 ± 0.08</td>
<td>0.06 ± 6x10^-3</td>
<td>2.45 ± 0.17</td>
</tr>
<tr>
<td>BHA</td>
<td>0.07 ± 3.0x10^-3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Epicatechin</td>
<td>-</td>
<td>6.6x10^-5 ± 4.8x10^-5</td>
<td>-</td>
</tr>
<tr>
<td>Rutin</td>
<td>-</td>
<td>-</td>
<td>0.24 ± 0.01</td>
</tr>
</tbody>
</table>

* Mean ± SD of triplicate values
As seen in Table 2, the HMG-CoA reductase inhibitory activity of persimmon (IC$_{50}$ = 0.71 ± 0.18 µg/mL) was higher than that of Atorvastatin (IC$_{50}$ = 1.76 ± 0.12 µg/mL) which is a standard inhibitor of the enzyme. The inhibitory action of radish (IC$_{50}$ = 1.81 ± 0.56 µg/mL) was close to that of the standard inhibitor. More so, lemon (IC$_{50}$ = 5.31 ± 0.80 µg/mL) and apple (IC$_{50}$ = 12.42 ± 2.53 µg/mL) also had intense inhibitory action on the enzyme. In contrast, onion, quince, pomegranate and grapefruit, respectively (IC$_{50}$ = 62.92 ± 2.94, 79.36 ± 3.94, 329.98 ± 163.14 and 13741.89 ± 3485.70 µg/mL) exhibited lower HMG-CoA reductase inhibitory activity. Statins are reported to be excellent inhibitors of HMG-CoA reductase. They help down-regulate cholesterol biosynthesis (Collins et al., 2016). Plant-based statins (such as lovastatin, pravastatin, and simvastatin) derived from sterols during the fermentation process play a significant role in cholesterol biosynthesis via HMG-CoA reductase inhibition, thus reducing the risk of cardiovascular diseases and infarction (Furberg et al., 1994; Byington et al., 1995; Pedersen et al., 1998; Furberg, 1999). The HMG-CoA reductase inhibitory activity of fruits and vegetables observed in the present study is likely due to the rich phytochemical composition of the plant, which is in the form of polyphenols, sterols, vitamins, and fatty acids.

Table 2: HMG-CoA reductase inhibition activity of ethyl alcohol extracts prepared from various plants

<table>
<thead>
<tr>
<th>Plant/Standard Inhibitor</th>
<th>Concentration (µg/mL)</th>
<th>Inhibition (%)*</th>
<th>IC$_{50}$ Values (µg/mL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quince</td>
<td>1.00</td>
<td>19.85 ± 4.9</td>
<td>79.36 ± 3.94</td>
</tr>
<tr>
<td></td>
<td>10.00</td>
<td>35.95 ± 0.78</td>
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<tr>
<td></td>
<td>100.00</td>
<td>55.60 ± 1.17</td>
<td></td>
</tr>
<tr>
<td>Apple</td>
<td>0.10</td>
<td>20.94 ± 4.87</td>
<td>12.42 ± 2.53</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>30.41 ± 8.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.00</td>
<td>45.91 ± 4.00</td>
<td></td>
</tr>
<tr>
<td>Grapefruit</td>
<td>1000.00</td>
<td>12.35 ± 4.64</td>
<td>13741.89 ± 3485.70</td>
</tr>
<tr>
<td></td>
<td>5000.00</td>
<td>17.82 ± 0.48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10000.00</td>
<td>42.73 ± 7.58</td>
<td></td>
</tr>
<tr>
<td>Lemon</td>
<td>0.10</td>
<td>6.35 ± 1.69</td>
<td>5.31 ± 0.80</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>29.68 ± 3.54</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.00</td>
<td>76.84 ± 6.83</td>
<td></td>
</tr>
<tr>
<td>Pomegranate</td>
<td>10.00</td>
<td>34.30 ± 1.18</td>
<td>329.98 ± 163.14</td>
</tr>
<tr>
<td></td>
<td>100.00</td>
<td>47.56 ± 11.85</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000.00</td>
<td>70.17 ± 0.58</td>
<td></td>
</tr>
<tr>
<td>Persimmon</td>
<td>0.01</td>
<td>36.87 ± 1.65</td>
<td>0.71 ± 0.18</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>42.64 ± 1.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>54.60 ± 3.27</td>
<td></td>
</tr>
<tr>
<td>Radish</td>
<td>0.10</td>
<td>37.95 ± 2.55</td>
<td>1.81 ± 0.56</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>47.57 ± 6.74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.00</td>
<td>82.95 ± 4.10</td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td>50.00</td>
<td>45.50 ± 1.44</td>
<td>62.92 ± 2.94</td>
</tr>
<tr>
<td></td>
<td>75.00</td>
<td>51.67 ± 3.45</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100.00</td>
<td>72.93 ± 4.81</td>
<td></td>
</tr>
<tr>
<td>Atorvastatin</td>
<td>0.50</td>
<td>4.81 ± 0.64</td>
<td>1.76 ± 0.12</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>30.37 ± 8.91</td>
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<tr>
<td></td>
<td>2.50</td>
<td>72.59 ± 2.79</td>
<td></td>
</tr>
</tbody>
</table>

* Mean ± SD of triplicate values
Conclusion

In conclusion, the fruits and vegetable extracts examined in the present study showed strong antioxidant activity. The plants also exhibited promising HMG-CoA reductase inhibition activity, especially persimmon and radish fruit. These potent antioxidant and inhibitory properties can be attributed to the rich phytochemical composition of plant extracts. Thus, it can be a potential source of new bioactive compounds effective against oxidative stress, hypercholesterolemia and cardiovascular complications.

Compliance with Ethical Standards

Conflict of interests: The author(s) declares that for this article, they have no actual, potential, or perceived conflict of interest.

Ethics committee approval: Authors declare that this study includes no experiments with human or animal subjects.

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Disclosure: -

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