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ARTICLE

In vitro Antiobesogenic and *In vivo* Anti-hyperlipidemic Effects of Selected Medicinal Plants

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Abstract

Medicinal plants are employed as curative measures for the management of different diseases in West Africa, e.g., obesity. The inhibition of amylase and lipase are important targets for anti-obesity drugs/agents; likewise, the inhibition of 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase for anti-hyperlipidemic drugs/agents. This study aimed to determine the anti-obesogenic and anti-hyperlipidemic activities of selected medicinal plants in *in vitro* and *in vivo* models, respectively. Ethanolic extracts and fractions of selected plants were initially screened *in vitro* against pancreatic lipase (p-nitrophenyl butyrate method) and alpha-amylase (starch-iodine method) at a concentration of 5 mg/ml, and the active plants were further screened at 1 mg/ml. Then, the half-maximal inhibitory concentration (IC_{50}) of plants that were active against alpha-amylase and lipase was determined. Thirty-five Wistar albino rats grouped into five were induced with hyperlipidemia using poloxamer 407 (1.0 g/kg bw) intraperitoneally with the normal, hyperlipidemic, and standard drug control groups being groups 1, 2, and 3, respectively. The plant extracts that were active against alpha-amylase were *L. aegyptiaca* (113 ± 0.14 µg/mL), *V. subterranea* (95.66 ± 0.12 µg/mL), *B. vulgaris* (262.3 ± 0.09 µg/mL), and *C. dactylon* (216 ± 0.15 µg/mL), with only *V. subterranea* (64.50 ± 0.84 µg/mL) and *O. gratissimum* (71.65 ± 0.12 µg/mL) extracts active against lipase. The n-butanol fraction of *O. gratissimum* and *V. subterranea* inhibited pancreatic lipase activity with an IC_{50} of 75.95 ± 0.47 and 55.41 ± 0.15 µg/mL respectively. The n-butanol fractions (150 and 300 mg/kg bw) of *V. subterrenea* and *O. gratissimum* revealed a significant decrease ($p < 0.05$) in triglyceride and total cholesterol compared to the hyperlipidemic control rats. In conclusion, the *V. subterranea* and *O. gratissimum* extracts and fractions had an inhibitory effect on pancreatic lipase, while only *V. subterranea* inhibited alpha-amylase, with both improving lipid profile, thus possessing anti-obesogenic and antihyperlipidemic properties.

Keywords: Hyperlipidemia, alpha-amylase, pancreatic lipase, *Vigna subterranea*, *Ocimum gratissimum*

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1.0 Introduction

Hyperlipidemia, commonly referred to as a comorbid condition of obesity, is medically marked by a high level of either one or all lipoproteins in the blood. Hyperlipidemia is indicated by total cholesterol levels of 240 mg/dL or higher, which usually results in various cardiovascular diseases (CVDs), including atherosclerosis and coronary heart disease (Su et al., 2021). In 2017, global estimates show that 17.8 million people died of CVDs, and this is projected be more than 23 million deaths by 2030 (Estruch et al., 2013; Jagannathan et al., 2019). World Heart Report (2023) recorded that 20.5 million deaths in 2021 resulted from CVD. Centre for Disease Control reported that in 2015-2016, 29 million adult Americans, which amounts to 12.4% of the population, had high total cholesterol (Carroll et al., 2017). Similarly, in Nigeria, over 21.9 million individuals aged 20 or older, representing 26%, were estimated to have hypercholesterolemia in 2015 (Adeloye et al., 2020). Serum HDL -C levels of less than 40 mg/dL are regarded as low, but levels of LDL over 100 mg/dl are regarded harmful (CDC, 2011; Su et al; 2021). The treatment for hyperlipidemia involves the use of a class of drugs known as statins, such as rosuvastatin, lovastatin, and simvastatin (Belichard et al., 1993, Su et al., 2021).

Obesity, a medical condition where excess body fat accumulates to a point where it could be harmful to wellbeing (WHO, 2015). An individual is categorized obese when body mass index (BMI) surpasses 30 kg/m^2 while a BMI between 25-30kg/m^2 is typically considered overweight (WHO, 2015). Global estimates show that there will be over 3 billion overweight and obese people in the world by 2030 (World Obesity Federation, 2025).

Conventional medicine prescribes weight loss medications that have several negative side effects and severe responses (Fahim et al., 2025). Surgery is frequently associated with surgical complications like infection, post-operative anastomotic fistula, thrombosis, anemia and malnutrition. Moreover, surgery is typically used to treat patients who are morbidly obese (BMI ≥ 40 kg/m2) or who have comorbidities like diabetes, hypertension and obstructive sleep apnea (Hawkins and Maheswaran, 2019). Given the shortcomings of Western medicine, surgery, and the dangers of obesity, researchers are on the lookout for alternative treatment options which involve the use of plant species that are vital for generating chemical compounds and extracts that can be used as a options which involve the use of plant species that are vital for generating chemical compounds and extracts that can be used as a raw material for developing treatment options for obesity and hyperlipidemia (Moro and Basile, 2000, Sun et al., 2018).

This study analyzed the crude extracts and fractions from selected plants of medicinal importance for their anti-obesity and antihyperlipidemic potency. These plants include *Ocimum gratissimum* (scent leaf), *Adansonia digitata* (Baobab), *Luffa aegyptiaca* commonly called sponge gourd, *Brassica oleracae* (Broccoli), *Beta vulgaris* (Beetroot), *Cynodon dactylon* (Bahama grass), *Dennetia tripetala* (Pepper fruit), and *Vigna subterranea* (Bambara groundnut). These plants have been reported to contain a lot of bioactive components which are associated with diverse benefits to health and wellness including obesity and are safe for consumption (Samec, 2011; Ramchoun *et al.*, 2009; Anyanwu *et al.,* 2013; Irondi *et al.*, 2017; Sokeng *et al.*, 2019; Egbong *et al.*, 2011; Mohammed *et al.*, 2007; Ogbonna *et al.,* 2013; Gilchrist, 2014).

2.0 Materials and Methods

2.1. Experimental Plant Extraction and Fractionation

Fresh fruits, leaves, and tubers of the selected plants were purchased from Mararaba market in the Karu, Nasarawa State, Nigeria. The plants were authenticated and given specimen number by Prof. J. Ihuma, Biological Sciences Department, Bingham University, Nasarawa State, Nigeria. Fresh portions of the plants, fruits, leaves, and tubers were cut into tiny pieces, allowed to dry at room temperature, and roughly ground. Maceration of the plant powder in ethanol lasted 3 days and filtration was done using filter paper. The filtrates were concentrated to a slurry at various temperatures with the aid of a rotary evaporator. The procedure for fractionation outlined by Hostettmann et al. (1991) involved floating each extract in 250 mL of water separately and using a separating funnel to partition the extracts with several organic solvents in increasing order of polarity. Plant extracts and fractions were dehydrated using solvent evaporation.

2.2 *In vitro* inhibitory enzymes activity of plants

The plant extracts and fractions were tested for inhibitory effect against porcine pancreatic lipase and alpha-amylase via the p-nitrophenylbutyrate methods (Kim *et al.*, 2009) and starch-iodine method (Xiao *et al.*, 2006) respectively as earlier described by Anyanwu et al. (2019).

2.3 Laboratory Animals

Exactly 35 Wistar albino rats were housed at the Animal Care Unit, Bingham University in various cages in groups of five. The rats were maintained throughout the experiment at room temperature under a 12:12 hour light/dark phases with adequate food and water supply. Prior to the investigation, ethical approval was obtained from Bingham University Ethical Research Committee Karu, Nasarawa State, Nigeria. A procedure described by OCDE (2002) was used to assess the acute toxicity level of plant fractions.

2.4 Hyperlipidemia induction and treatment

Hyperlipidemia was induced using poloxamer 407 (P407) using a method outlined by Wout et al. (1993) and Johnston and Palmer (1993). To speed up the dissolution process, P407 was dissolved in regular saline and chilled for the entire night in the fridge. To avoid gelation within the syringe during the injection, the syringes and needles used for the administration were also refrigerated. Following an overnight fast, rats in groups 2-7 were injected with P407 intraperitoneally at a rate of 1 g/kg body weight. Three hours later, higher levels of triglycerides and total cholesterol in animals were confirmed. This was followed with an oral administration of 75 mg/kg rosuvastatin, 150 and 300 mg/kg bw plant fractions for three days. Tail blood samples were taken from every animal before administering poloxamer, as well as at three, twenty-four, and forty-eight hours later to confirm induction.

2.5 Data analysis

The IC_{50} values for the *in vitro* digestive enzyme assay were determined using the GraphPad Prism v5, while the means and standard error of means for the *in vivo* study were calculated by one-way analysis of variance with Duncan Multiple comparison test at $p < 0.05$ significant level via the Statistical Package for the Social Sciences v16 software.

3. Results

3.1 Inhibitory activity of plants against digestive enzymes

The ethanol extracts of *L. aegyptiaca*, *B. vulgaris, C. dactyon* and *V. subterranea* inhibited alpha amylase with values above 50%, while *A. digitata*, *B. oleracea*, *L. aegyptiaca*, and *O. gratissimum* had values less than 50% and were considered inactive (Figure 1, Table 1). Ethanolic extracts of *O. gratissimum, B oleracea*, *V. subterranea* and *A. digitata* inhibited lipase (Figure 2, Table 1), while *B. vulgaris*, *C. dactylon*, *D. tripetala*, and *L. aegyptiaca* did not because they had less than 50% inhibition. For the fractions of the most active plants, n-butanol fraction of *O. gratissimum* inhibited lipase, while that of *V. subterranea* inhibited alpha-amylase as well as lipase (Figures 3 and 4, Table 1), thus these plant fractions were included in *in vivo* studies.

The n-butanol fractions of *O. gratissimum* and *V. subterranea* posed no harm to the rats as no death was recorded after administering 2000 mg/kg bw single oral dose. During the study, there was also no adverse effect of the fractions recorded. A significant decrease ($p < 0.05$) in TG levels was noticed at 24 hours in the treated rats (*O. gratissimum*, *V. subterranea* and rosuvastatin) compared to the hyperlipidemic control group which seemed to have weaned after 48 hours as no significant change ($p < 0.05$) ensued between the treated groups and the hyperlipidemic control group. For groups treated with *V. subterranea*, at 24 hours, the triglyceride levels for the 300 mg/kg group significantly reduced compared to the hyperlipidemic group. After 48 hours, a significant decrease was recorded in triglyceride levels of groups 3-5 in comparison to the hyperlipidemic control (Table 2).

When comparing the treated groups (*O. gratissimum*, *V. subterranea*, and rosuvastatin) to the normal group, a significant elevation ($p < 0.05$) in HDL-C levels was only seen at 24 hours. However, after three hours, the treated group (300 mg/kg of *O. gratissimum*) showed a significant increase in HDL-C levels relative to the hyperlipidemic control rats. When comparing the treatment groups (300 mg/kg of *O. gratissimum* and rosuvastatin) to the hyperlipidemic rats after 48 hours, the HDL-C levels were significantly declined in the treated groups (Table 3).

After twenty-four hours, the LDL-C of the treated group (150 mg/kg *O. gratissimum*) was significantly higher ($p < 0.05$) than the hyperlipidemic control. However, the LDL-C of the treated group (*O. gratissimum*-300 mg/kg) was significantly declined ($p < 0.05$) relative to the hyperlipidemic control, whereas it was significantly higher ($p < 0.05$) in the treated group (*V. subterranea*-300 mg/kg). Notably, all treatment groups' LDL-C significantly decreased (Table 4), compared to the hyperlipidemic control at 48 hours.

CHOL/HDL after 24 hours significantly declined ($p < 0.05$) in the hyperlipidemic control and treated groups (rosuvastatine and *V. subterranea*-150mg/kg) compared to the normal control (Table 5). A significant decline was observed ($p < 0.05$) in CHOL/HDL in groups treated with rosuvastatine and 300 mg/kg n-butanol fraction of *O. gratissimum*, while a significant decrease ($p < 0.05$) ensued in the treated (150 mg/kg) compared to the hyperlipidemic control group after 48 hours. Levels of LDL-C declined significantly ($p < 0.05$) in all treated groups after forty-eight hours in comparison to the hyperlipidemic control.

After three hours, all induced groups had considerably higher TC levels ($p < 0.05$) than the hyperlipidemic and treated groups, indicating that poloxamer 407 had successfully induced hyperlipidemia. After 24 hours, groups treated with *V. subterranea* displayed a significant increase in TC levels than the normal control rats, but not the hyperlipidemic control group. Conversely, groups treated with *O. gratissimum* displayed a significant decrease ($p < 0.05$) in TC when compared to the hyperlipidemic control. Rats treated with *O. gratissimum*, *Vigna subterranea*, and Rosuvastatin had significantly lower total cholesterol levels ($p < 0.05$) after 48 hours when compared to the hyperlipidemic control group (Table 6).

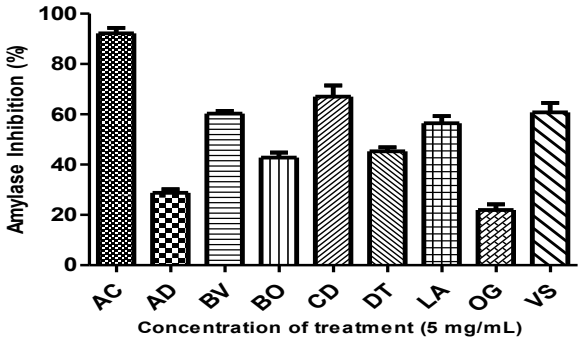

Figure 1: Percentage inhibition of plants extracts against α-amylase activity at 5 mg/mlAC- Acarbose, AD- *Adansonia digitata*, BV- *Beta vulgaris*, BO- *Brassica oleracea*, CD- *Cynodon dactylon*, DT- *Dennettia tripetala*, LA- *Luffa aegyptiaca*, OG- *Ocimum gratissimum*, VS- *Vigna subterranea*

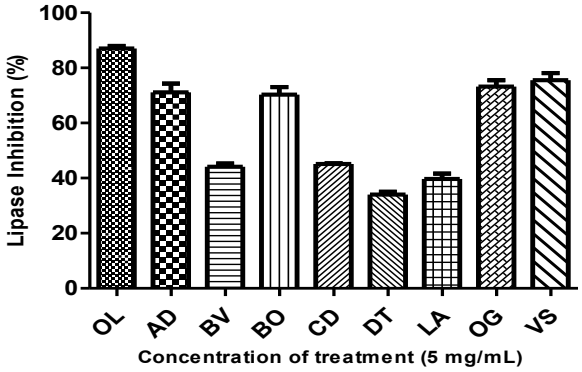

Figure 2. Percentage inhibitory activity of plant extract against porcine pancreatic lipase at 5mg/ml
OL- Orlistat, AD- *Adansonia digitata*, BV- *Beta vulgaris*, BO- *Brassica oleracea*, CD- *Cynodon dactylon*, DT- *Dennettia tripetala*, LA- *Luffa aegyptiaca*, OG- *Ocimum gratissimum*, VS- *Vigna subterranea*

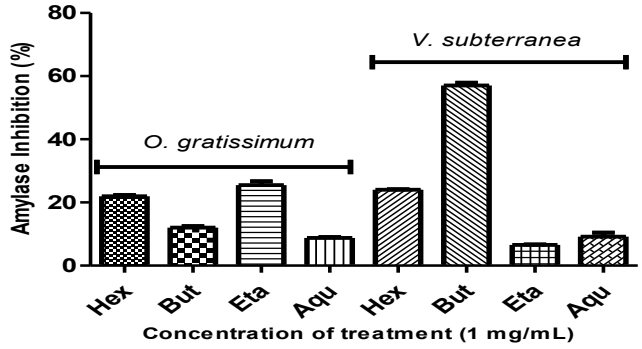

Figure 3. Percentage inhibition of fractions of *O. gratissimum* and *V. subterranea* against alpha-amylase at 1mg/ml. Hex- n-Hexane, But- n-Butanol, Eta- Ethyl acetate, Aqu- Aqueous.

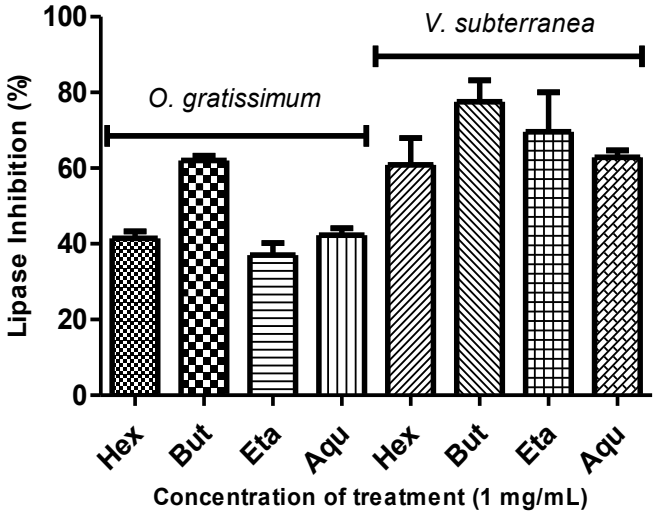

Figure 4. Percentage inhibition of fractions of *O. gratissimum* and *V. subterranea* against porcine pancreatic lipase at 1 mg/ml. Hex- n-Hexane, But- n-Butanol, Eta- Ethyl acetate, Aqu- Aqueous.

Table 1. IC_{50} values of plant extract and fractions against α-amylase and lipase

Plants	Mode of plant	Lipase IC_{50} (µg/mL)	α-amylase IC_{50} (µg/mL)
AD- *Adansonia digitata*	ECE	78.45 ± 0.33	ND
BV- *Beta vulgaris*	ECE	ND	262.3 ± 0.09
BO- *Brassica oleracea*	ECE	84.70 ± 0.25	ND
CD- *Cynodon dactylon*	ECE	ND	216 ± 0.15
DT- *Dennettia tripetala*	ECE	ND	ND
LA- *Luffa aegyptiaca*	ECE	ND	113 ± 0.14
OG- *Ocimum gratissimum*	ECE	71.65 ± 0.12	ND
	n-butanol fraction	75.95 ± 0.47	ND
VS- *Vigna subterranea*	ECE	64.50 ± 0.84	95.66 ± 0.12
	n-butanol fraction	55.41 ± 0.15	104.1 ± 0.10
Orlistat		0.11 ± 0.02	NA
Acarbose		NA	19.44 ± 0.08

Note: ECE- Ethanol crude extract; ND- not determined; NA- not applicable

Table 2. Triglycerides levels (mmol/L) of n-butanol fraction treated rats

Groups	0 hours	3 hours	24 hours	48 hours
Normal control	0.62 ± 0.04^{a}	0.60 ± 0.03^{b}	0.64 ± 0.03^{d}	0.63 ± 0.04^{b}
Hyperlipidemic control	0.74 ± 0.09^{a}	3.04 ± 0.24^{a}	2.35 ± 0.09^{a}	1.63 ± 0.16^{a}
Rosuvastatin (75mg/kg)	0.91 ± 0.25^{a}	2.91 ± 0.18^{a}	1.90 ± 0.15^{b}	1.43 ± 0.06^{a}
Ocimum gratissimum (150 mg/kg)	0.61 ± 0.01^{a}	3.04 ± 0.02^{a}	1.59 ± 0.06^{c}	1.53 ± 0.16^{a}
Ocimum gratissimum (300 mg/kg)	0.61 ± 0.01^{a}	3.04 ± 0.01^{a}	1.82 ± 0.03^{c}	1.38 ± 0.02^{a}
Vigna subterranea (150 mg/kg)	0.58 ± 0.02^{a}	3.12 ± 0.04^{a}	2.26 ± 0.03^{a}	1.43 ± 0.14^{a}
Vigna subterranea (300 mg/kg)	0.62 ± 0.07^{a}	0.74 ± 0.06^{b}	1.58 ± 0.10^{c}	1.48 ± 0.08^{a}

Means ± SEM sharing similar alphabetic superscripts in a column are not significantly different at $p < 0.05$.

Table 3. High density lipoprotein levels (mmol/L) of n-butanol fraction treated rats

Groups	0 hours	3 hours	24 hours	48 hours
Normal Control	0.40 ± 0.01^{a}	0.42 ± 0.01^{b}	0.40 ± 0.01^{b}	0.41 ± 0.02^{b}
Hyperlipidemic control	0.42 ± 0.02^{a}	0.46 ± 0.01^{b}	2.53 ± 0.02^{a}	2.56 ± 0.03^{a}
Rosuvastatin (75mg/kg)	0.41 ± 0.01^{a}	1.28 ± 0.53^{a}	2.33 ± 0.28^{a}	0.47 ± 0.05^{b}
O. gratissimum (150 mg/kg)	0.39 ± 0.01^{a}	0.42 ± 0.01^{b}	1.86 ± 0.73^{ab}	2.56 ± 0.01^{a}
O. gratissimum (300 mg/kg)	0.38 ± 0.02^{a}	1.83 ± 0.03^{a}	1.86 ± 0.73^{ab}	0.46 ± 0.02^{b}
V. subterranea (150 mg/kg)	0.41 ± 0.02^{a}	2.15 ± 0.03^{a}	2.62 ± 0.04^{a}	1.16 ± 0.67^{b}
V. subterranea (300 mg/kg)	0.41 ± 0.02^{a}	0.47 ± 0.06^{c}	0.43 ± 0.08^{b}	0.40 ± 0.01^{b}

Means ± SEM sharing similar alphabetic superscripts in a column are not significantly different at $p < 0.05$.

Table 4. LDL levels (mmol/L) of n-butanol fraction treated rats

Groups	0 hours	3 hours	24 hours	48 hours
Normal control	1.93 ± 0.03^{a}	1.91 ± 0.01^{a}	1.92 ± 0.02^{ab}	1.92 ± 0.01^{b}
Hyperlipidemic control	1.85 ± 0.05^{a}	1.78 ± 0.10^{a}	1.02 ± 0.28^{bc}	3.31 ± 0.38^{a}
Rosuvastatin (75mg/kg)	1.80 ± 0.13^{a}	0.74 ± 0.30^{b}	1.40 ± 0.31^{bc}	1.53 ± 0.10^{c}
O. gratissimum (150 mg/kg)	1.90 ± 0.04^{a}	0.80 ± 0.03^{b}	3.30 ± 0.08^{a}	1.48 ± 0.05^{c}
O. gratissimum (300 mg/kg)	1.92 ± 0.04^{a}	0.63 ± 0.05^{c}	0.10 ± 0.85^{c}	2.16 ± 0.12^{b}
V. subterranea (150 mg/kg)	1.62 ± 0.10^{b}	1.60 ± 0.26^{a}	2.18 ± 0.01^{b}	1.58 ± 0.06^{b}
V. subterranea (300 mg/kg)	1.91 ± 0.04^{a}	1.83 ± 0.02^{a}	4.80 ± 0.19^{a}	1.88 ± 0.12^{b}

Means ± SEM sharing similar alphabetic superscripts in a column are not significantly different at $p < 0.05$.

Table 5. CHOL/HDL ratio of n-butanol fraction treated rats

Groups	0 hours	3 hours	24 hours	48 hours
Normal Control	6.54 ± 0.15^{a}	6.15 ± 0.13^{a}	6.56 ± 0.06^{a}	6.35 ± 0.20^{a}
Hyperlipidemic control	6.25 ± 0.21^{a}	5.76 ± 0.12^{a}	1.82 ± 0.11^{d}	2.58 ± 0.13^{b}
Rosuvastatin (75mg/kg)	6.45 ± 0.20^{a}	3.04 ± 1.33^{b}	2.04 ± 0.27^{c}	5.80 ± 0.60^{a}
O. gratissimum (150 mg/kg)	6.55 ± 0.10^{a}	6.26 ± 0.15^{a}	6.67 ± 4.45^{a}	2.11 ± 0.02^{b}
O. gratissimum (300 mg/kg)	6.45 ± 0.20^{a}	1.41 ± 0.04^{b}	3.08 ± 2.04^{b}	5.57 ± 0.06^{a}
V. subterranea (150 mg/kg)	6.17 ± 0.08^{a}	5.49 ± 0.12^{b}	2.24 ± 0.00^{c}	5.02 ± 0.55^{c}
V. subterranea (300 mg/kg)	6.32 ± 0.19^{a}	5.60 ± 0.06^{b}	13.95 ± 0.55^{a}	7.40 ± 0.30^{a}

Means ± SEM sharing similar alphabetic superscripts in a column are not significantly different at $p < 0.05$.

Table 6. Total cholesterol levels (mmol/L) of n-butanol fraction treated rats

Groups	0 hours	3 hours	24 hours	48 hours
Normal control	2.60 ± 0.01^{a}	2.60 ± 0.01^{a}	2.60 ± 0.01^{c}	2.62 ± 0.01^{c}
Hyperlipidemic control	2.60 ± 0.01^{a}	2.63 ± 0.01^{a}	4.61 ± 0.28^{b}	6.61 ± 0.40^{a}
Rosuvastatin (75mg/kg)	2.62 ± 0.01^{a}	2.63 ± 0.01^{a}	4.59 ± 0.10^{c}	2.65 ± 0.05^{c}
O. gratissimum (150 mg/kg)	2.57 ± 0.04^{a}	2.60 ± 0.02^{a}	5.87 ± 0.12^{a}	5.41 ± 0.05^{b}
O. gratissimum (300 mg/kg)	2.58 ± 0.05^{a}	2.57 ± 0.02^{a}	2.59 ± 0.12^{C}	2.57 ± 0.04^{C}
V. subterranea (150 mg/kg)	2.61 ± 0.01^{a}	2.62 ± 0.01^{b}	5.740 ± 0.05^{a}	2.71 ± 0.01^{b}
V. subterranea (300 mg/kg)	2.61 ± 0.01^{a}	2.63 ± 0.01^{a}	5.947 ± 0.19^{a}	2.96 ± 0.09^{b}

Means ± SEM sharing similar alphabetic superscripts in a column are not significantly different at $p < 0.05$.

4. Discussion

4.1. Porcine pancreatic lipase inhibitory activity on plants

The ethanolic plant extracts of *O. gratissimum*, *B. oleracae, V. subterranea* and *A. digitata* displayed pancreatic lipase inhibitory activity and thus might possess the abilities to reduce fat absorption, therefore possessing antiobesity properties as claimed by traditional medicine users. The n-butanol fraction of *O. gratissimum* and *V. subterranea* were also active against the pancreatic lipase enzyme.

Researchers have directed more of their attention towards the discovery of novel pancreatic lipase inhibitors with fewer side effects in an effort to find natural solutions for treating obesity (Liu et al., 2020; Citriniti et al., 2025).

Through its ability to hydrolyze triacylglycerols into monoacylglycerols and fatty acids, pancreatic lipase plays a crucial role in the absorption of dietary triacylglycerols (Miller and Lowe, 2008). It enters the duodenum through the pancreatic duct system and hydrolyzes between 50 and 70 percent of all ingested fats (Birari and Bhutani, 2007), which makes it an important target for weight reduction research. Lipase inhibition lowers fat absorption because it interferes with the breakdown of fat, which limits the amount of lipids that are used after ingestion (Slanc et al., 2009). The inhibition of pancreatic lipase by fractions and ethanolic extracts of plants has been documented by Seyedan et al. (2015).

The plant extracts of *O. gratissimum*, *B. oleracae* and *A. digitata* as well as the n-butanol fraction of *O. gratissimum* and *V. subterranea* might be exerting this action by inhibiting the absorption of fatty acids and preventing the process that leads to its accumulation. This implies that the bioactive compounds responsible for exerting such effect are possibly in high amounts in these fractions. The bioactive compounds may include polyphenols, such as flavonoids, anthocyanins, terpenes and saponins which have been reported as pancreatic lipase inhibitors (Papoutsis et al., 2021).

4.2. Alpha amylase inhibitory activity on plants

L. aegyptiacae, Beta vulgaris, Cynodon dactylon, and Vigna subterranea extracts inhibited the activity of alpha amylase *in vitro*. Alpha-amylase inhibitors are known to lessen post-meal glucose peaks by delaying the rate at which amylase breaks down starch into simple sugar until the body has a chance to react to it (Ogunyemi et al., 2022). Lowering the blood sugar level after a meal stops the absorption of glucose into adipose tissue to suppress the production and build-up of triacylglycerol (Hiyoshi et al., 2017). According to Bhandari et al. (2008), many medicinal plants crude extracts have α-amylase inhibitory activity whose claim has been validated by various studies (Wickramaratne et al., 2016; Khadayat et al., 2020; Oyedemi et al., 2017). Certain bioactive ingredients responsible for inhibitory activity against alpha amylase are contained in crude extracts as well as fractions of various plants (Anyanwu et al., 2021). Additionally, inhibition of α-amylase, a carbohydrate hydrolysing enzyme, is a valid mode of action for some obesity drugs (Jayaraj et al., 2013).

This indicates that alpha amylase inhibition by the active plants possibly inhibits the breakdown of α-(1, 4)-glycosidic linkages in the starch components and glycogen thereby reducing the absorption of dietary carbohydrate and as such, there are possible bioactive compounds contained in these plants that serve these purposes.

4.3. Effect of plants fractions on hyperlipidemic rats

Following induction with poloxamer 407 at a dose of 1g/kg, the rats developed a hyperlipidemic state due to the aberrant increases of lipids (Wout et al., 1992; Wasan et al., 2003).

Following treatment with n-butanol fraction of *O. gratissimum* and *V. subterrenea*, there was an increase in HDL-C but a decrease in TG, TC, and LDL-C levels. Hyperlipidemia is a major risk factor for developing coronary heart diseases (CHDs), that results in atherosclerosis (Linton et al., 2019). Elevated levels of LDL-C poses as a key risk factor for coronary heart disease and HDL-C acts as a cardio-protective protein (Ali et al., 2012). That the plant fractions effectively lowered the levels of TG, TC and LDL indicates that it might have opposed the effect of poloxamer 407 by inhibiting the HMG-CoA reductase which induced high lipid levels in the rats by stimulating the activity of the same enzyme (Johnson and Palmer 1993; Palmer et al., 1997). Therefore, these plants might be effective in the aversion of coronary heart disease resulting from high lipid levels.

Lecithin-cholesterol acetyl transferase, which is involved in the reverse cholesterol transport route and converts small pre-β HDL into bigger, spherically-shaped α-migrating forms of HDL, may be the cause of the significant rise in HDL-C (Rousset et al., 2011).

HDL-C has anti-atherogenic properties evidenced by its inhibition of LDL-C oxidation and transport of CHOL from peripheral tissues, like artery walls, to the liver for hepatic metabolism (Choi *et al.*, 1991; Kwiterovich 1998).

A decrease in triglyceride levels could result from suppression of lipolysis, which prevents fatty acids from being converted to triglycerides, or from increased activity of lipoprotein lipase bound in the endothelium which hydrolyzes triglycerides into fatty acids (Feingold, 2021). Since elevated levels of TG, TC, and LDL-C majorly result in increased cases of heart disease and stroke, the effect of these plant fractions in lowering them insinuates that they could participate in reducing the severity of heart diseases. This is collaborated with results from diverse studies which has shown that plant extracts and fractions proved effective in the lowering of high lipid levels (Ramchoun et al.,2012; Ramchoun et al., 2020; Anyanwu et al., 2021; Fadhlina et al., 2023). *V. subterranea and O. gratissimum* at 150mg/ml reduced the CHOL/HDL ratio. When low, CHOL/HDL ratio is associated with a reduced risk of cardiovascular diseases (Jeppesen, Facchini and Reaven, 1998). Therefore, the lowering effect of these plant fractions on CHOL/HDL ratio implies that it could help reduce the risk of cardiovascular diseases.

5. Conclusion

The results from this research clearly validate the antihyperlipidemic activity of *O. gratissimum* and *V. subterranea* fractions *in vivo* evidenced by their decreasing effect on triglyceride, low density lipoprotein, total cholesterol and CHOL/HDL levels. They were also confirmed to have inhibited pancreatic lipase, but only *V. subterranean* inhibited alpha amylase *in vitro*. Therefore, they might serve as potent agents in the research for anti-obesity compounds which can be drug candidates.

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