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(RESEARCH ARTICLE)

Elucidation of the effects of combined administration of Zingiber officinale and Allium sativum ethanol extracts on lipid profile by means of female Wister rat models

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Abstract

Dyslipidemia is a metabolic condition that is marked by abnormal levels of serum cholesterol (CHO), triglyceride (TG), high density lipoprotein (HDL), low density lipoprotein (LDL), and very low density lipoprotein (VLDL). Elevation of CHO, TG, LDL and VLDL can lead to cardiovascular diseases such as myocardial infarction and stroke. In this study, the influence of *Allium sativum* and *Zingiber officinale* ethanol extracts on the various lipid components when administered in monotherapy and in combination therapy were evaluated using female Wister rat models. Mature female Wister rats (n = 40) were divided into eight groups. Group 1 was the control group and received 10 ml/kg body weight of distilled water. Group 2 and 3 received 530 mg/kg body weight of *Zingiber officinale* and *Allium sativum* respectively. Groups 4-8 were treated with different ratios of the two herbs administered in combination (*Zingiber officinale*:*Allium sativum*). The ratios were 2;8, 4:6, 5:5, 6:4, and 8:2. On the 91st day post treatment, blood samples were collected from the animals in all the groups and analyzed for the lipid components notably CHO, TC, TG, HDL, LDL, and VLDL. It was observed that *Allium sativum* given alone had the best effects on all the lipid components which was significant ($P < 0.05$). It can be concluded that *Allium sativum* administered alone exhibited the greatest potentials in lowering bad cholesterol (TG, TC, LDL and VLDL) as well as increasing the good cholesterol (HDL) than *Zingiber officinale* or combination of the two herbs administered in all proportions.

Keywords: *Allium sativum*; Cholesterol; High density lipoprotein; Lipid profile; *Zingiber officinale*

1. Introduction

Dyslipidemia is a metabolic condition that is marked by abnormal levels of serum cholesterol, triglyceride (TG), high density lipoprotein (HDL), low density lipoprotein (LDL), and very low density lipoprotein (VLDL). Dyslipidemia is a critical yet controllable risk factor of cardiovascular diseases and causes many deaths globally. Approximately half the popular risk of myocardial infarction and one-quarter of ischemic stroke risk are estimated by elevated LDL and cholesterol levels [1]. In the same study, it was established in the world that lipid disorders promote the development of atherosclerosis and its clinical consequences. The study aimed at assessing the impacts of a Persian medicinal (PM) compound on lipid profile. The researchers conducted a randomized double-blind controlled clinical trial with 74 dyslipidemia patients, who were randomly divided into two equally populated groups: one prescribed with a Persian medicinal herbal compound (n = 37) and a placebo group (n = 37). A Persian herbal medicine including fenugreek, sumac, and purslane were introduced. Biochemical parameters including 12-hour fasting serum levels of total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), very-low-density lipoprotein (VLDL), and triglyceride (TG) were measured before the initiation and after the completion of study protocol. Percent changes of

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biochemical parameters include the following: intervention group = cholesterol: 35.22, Tg: 45.91, LDL: 24.81, HDL: 2.05, VLDL: 8.94 and placebo group = cholesterol: 6.94, Tg: −7.3, LDL: 7.37, HDL: 2.88, VLDL: −0.14. The serum levels of total cholesterol (p=0.01) and LDL (p=0.01) significantly decreased and no increase was recorded in HDL (p=0.03) levels over time in the intervention group. Furthermore, between-group analysis showed a statistically significant difference between the intervention and placebo groups in this regard. VLDL (p=0.2) and TG (p=0.2) levels also decreased, however not significantly. In conclusion, this study showed that a Persian medicinal herbal compound could be safe and beneficial to decrease the levels of serum cholesterol and LDL in dyslipidemia patients [1].

Zingiber officinale which belongs to the family zingiberaceae and its edible underground rhizome is consumed worldwide both as a spice and as a herbal medicine. *Zingiber officinale* medicinal value has been employed in the treatment of various health conditions such as gastrointestinal disorders. *Zingiber officinale* also contains numerous phytocomponents which exhibit anti-oxidative, anti-inflammatory, anticancer, anti-diabetic, antiemetic, cardiovascular effects among others. A certain study further confirmed that *Zingiber officinale* has antitussive, antipyretic, antiasthma and cough suppressant effects [2]. The rhizome of *Zingiber officinale* contains a wide variety of biologically active compounds such as phenolic and terpene compounds. The phenolic compounds in *Zingiber officinale* are mainly gingerols, shogaols, and paradols. In newly harvested *Zingiber officinale*, gingerols are the major polyphenols, such as 6-gingerol, 8-gingerol, and 10-gingerol. With heat treatment or long-time storage, gingerols can be transformed into corresponding shogaols. After hydrogenation, shogaols can be transformed into paradols. Other phenolic compounds in ginger include quercetin, zingerone, gingerenone-A, and 6-dehydrogingerdione while terpene components include β-bisabolene, α-curcumene, zingiberene, α-farnesene, and β-sesquiphellandrene, which are considered to be the main constituents of *Zingiber officinale* essential oils. Besides these, polysaccharides, lipids, organic acids, volatile oils, and raw fibers are also present in *Zingiber officinale* [3]. The distinctive odor and flavor of ginger are due to these volatile oils. The volatile oils consist mainly of sesquiterpene hydrocarbons, predominantly zingiberol which gives rise to the characteristic aroma of ginger. In another study that involved phytochemical screening, both the aqueous and petroleum ether extract of ginger contain alkaloids, saponins, flavornoids, polyphenols, cardiac glycosides and reducing sugars. According to the researchers, the mineral elements contained in ginger include iron (Fe), chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn), and cadmium (Cd) [4]. Due to the wide variety of bioactive compounds in ginger, it exhibits a lot of pharmacological activities.

Allium sativum on the other hand is an herb growing from a strongly aromatic, rounded bulb comprising around 10 to 20 cloves covered in a papery coat. The leaves are long with sword-shape and are attached to an underground stem. The greenish-white or pinkish flowers grow in dense, spherical clusters on top of a flower stalk. *Allium sativum* has been used since ancient times for its medicinal properties. Its bulbs are found in many traditional medicines. In India, a juice or paste prepared from *Allium sativum* bulbs has traditionally been used to relieve coughs, fevers, and ear aches, as well as improve skin conditions. In Ayurvedic and Siddha medicine, *Allium sativum* juice has been used to alleviate sinus problems. Extracts from dried *Allium sativum* bulbs have been used in Unani medicine to regulate menstruation and treat digestive problems and fevers. Hot water extracts from *Allium sativum* bulbs mixed with honey were a folk remedy for whooping cough and intestinal worms. In Pakistan, an *Allium sativum* extract is traditionally taken orally to settle the stomach, treat coughs and reduce fever. In Nepal, East Asia and the Middle East, it has been used to treat fevers, digestive and lung problems, and high blood pressure, among other illnesses. Some studies have shown that sulphur-containing compounds in garlic, like allicin, may have anti-bacterial, anti-fungal, anti-viral, and antioxidant properties [5]. According to the researchers, they may also provide pain relief, support immune function, and help lower blood glucose and blood pressure. In a certain study, *Allium sativum* was described as a perennial plant of the amaryllis family (Amaryllidaceae), grown for its flavorful bulbs. The plant is native to central Asia but grows wild in Italy and southern France and is a classic ingredient in many national cuisines. The bulbs have a powerful onion like aroma and pungent taste and are not usually eaten raw ([6]. *Allium sativum* was recognized for its potentials to treat and prevent various diseases including cardiovascular problems, common cold, bacterial and fungal infections. *Allium sativum* extracts showed good antibacterial activity against selected pathogenic bacterial cultures including Pseudomonas, Bacillus, Shigella and Salmonella. Sliver nanoparticles were also synthesized with the aid of garlic extract and were characterized by X-Ray diffraction. Synthesized silver nanoparticles showed good antibacterial activity against all Salmonella followed by Bacillus, Shigella and Pseudomonas [7]. Another study involves the qualitative phytochemical analysis of two different medicinal plants: *Allium sativum* and *Curcuma longa* locally available in Pantnagar, region of Uttarakhand. In the study, aqueous and ethanol extract samples were used for qualitative preliminary phytochemical analysis using standard chemical tests. The results from the study indicated the presence of proteins, phlobutanin, ketones, phenolic compounds, cardiac glycosides flavonoids, alkaloids and tannins [8]. In another study, some researchers noted that the amount of organosulfur in garlic extract was 70.91% and the most common organosulfur compounds were trisulfide, di-2-propenyl (34.8%) and diallyl disulfide (14.83%). [9]. Further study investigated the qualitative analysis of the major bioactive constituents of medicinally important plants such as *Allium sativum* and *Andrographis paniculata* in its aqueous solution. The phytochemical tests were conducted using standard methods of analysis. The result of the

phytochemical screening showed the presence of saponin, terpenoid, flavonoids, amino acid and protein, volatile oil and cardiac glycosides, whereas *Andrographis paniculata* contains saponin, tannin, phenol, alkaloids, terpenoid, phlobatannin, volatile oil, hydrolysable tannin and glycosides. Vitamin C was absent in both *Allium sativum* and *Andrographis paniculata* [10]. The practice of complementary and alternative medicine is now on the increase in developing countries in response to World Health Organization's directives. This has culminated in several pre-clinical and clinical studies that have provided the scientific basis for the efficacy of many plants used in folk medicine to improve growth performance in farm animals and treat infections. Due to its biologically active components that contribute to its pharmacological properties, *Allium sativum* is used in the drug development for various human diseases. To obtain crucial data and scientific knowledge about the therapeutic uses of garlic, systematic literature searches were conducted using key terms on well-known indexed platforms such as PubMed, Scopus, Web of Science, Medline, Embase, and popular search engines. *Allium sativum* was found to have fundamental nutritional components notably carbohydrates, protein, fat, minerals, water, and vitamins are all found in abundance in this plant. *Allium sativum* is effective as anti-inflammatory, rheumatological, ulcer inhibiting, anticholinergic, analgesic, antimicrobial, antistress, antidiabetes, anticancer, liver protective, anthelmintics, antioxidants, antifungal, and wound healing agent. It also has properties that help in treating asthma, arthritis, chronic fever, tuberculosis, runny nose, malaria, leprosy, skin discoloration, and itching, indigestion, colic, enlarged spleen, hemorrhoids, fistula, bone fracture, gout, urinary tract disease, diabetes, kidney stones, anemia, jaundice, epilepsy, cataract, and night blindness. The researchers concluded that the nutritional content of the plant is significant, and it has incredible therapeutic potential [11]. The influence of *Allium sativum* and *Zingiber officinale* ethanol extracts on lipid profile when administered in monotherapy and in combination therapy was evaluated using female Wister rat models.

2. Material and methods

2.1. Materials

2.1.1. Animals

Mature female Wister rats (140.6 – 145.4 g) and aged (2-3 months) were procured from the Animal house of the faculty of Pharmaceutical sciences, Nnamdi Azikiwe University Awka, Agulu Campus. The animals were acclimatized for 14 days under standard conditions of temperature and illumination (12 hours dark: 12 hours light) cycle. The rats were fed commercially available rat's pellets and given access to drinking water ad libitum. Ethical approval was obtained from the Nnamdi Azikiwe University Animal Research and Experiment Committee (Approval number: NAU/AREC/2023/00021).

2.1.2. Plant materials

The plants used in this researched were *Zingiber officinale* rhizome and *Allium sativum* bulb. These plants were procured in a market in Enugu state of Nigeria.

2.2. Methods

2.2.1. Extraction of the active components

The plant sources, fresh *Zingiber officinale* rhizome and *Allium sativum* bulb, after being purchased from the market were washed and dried. After drying they were pulverized separately. 200 g of each pulverized plant parts was macerated in one liter of ethanol for 48 hours. The filtrates was collected by sieving through a muslin cloth. The filtrates were concentrated in a water bath at 50 °C and stored in the refrigerator until used.

2.2.2. Phytochemical analysis of Zingiber officinale and Alliun sativum separately

The qualitative phytochemical analysis of the extract and fractions were carried out using standard methods described by Peter *et al*., (2023) [12].

2.2.3. Acute toxicity studies (LD50) of Zingiber officinale and Allium sativum ethanol extracts

The actual median lethal dose (LD_{50}) estimation of the *Zingiber officinale* and *Allium sativum* ethanol extracts were conducted with the method described by Lorke, (1983) [13]; with modifications in accordance with the description by Peter *et al*., (2023) [12].

2.3. Experimental design

A total of 40 mature female Wister rats were divided into 8 groups of 5 rats per group. Groups 1 rats were treated with distilled water and served as the normal control. Group 2 were treated with *Zingiber officinale* ethanol extract alone. Group 3 were treated with *Allium sativum* ethanol extract alone. Group 4 were treated with combined administration of *Zingiber officinale* ethanol extract and *Allium sativum* ethanol extract (ratio = 2:8). Group 5 were treated with combined administration of *Zingiber officinale* ethanol extract and *Allium sativum* ethanol extract (ratio = 4:6). Group 6 were treated with combined administration of *Zingiber officinale* ethanol extract and *Allium sativum* ethanol extract (ratio = 5:5). Group 7 were treated with combined administration of *Zingiber officinale* ethanol extract and *Allium sativum* ethanol extract (ratio = 6:4). Group 8 were treated with combined administration of *Zingiber officinale* ethanol extract and *Allium sativum* ethanol extract (ratio = 8:2). Treatment were administered for 3 months (90 days). Doses were selected based on the results of the acute toxicity studies. On the 91st day of treatment after administration of the 90th doses, blood samples were collected by ocular puncture from all the rats from each of groups 1-8 for sub-chronic lipid profile analysis.

2.4. Biochemical assay of lipid profile

Lipid parameters were assayed using standard serum lipid assay kits (Fortress Diagnostics Ltd, Antrim, UK) as described by Igharo *et al*., (2020) [14].

2.4.1. Quantitative determination of total cholesterol

Using the cholesterol kit, the working reagent was prepared by using one vial of the enzyme reagent R2 dissolved in 10 ml of buffer R1. This was mixed well and allowed to stay for 15 min before use. To 10 µL of either the sample or standard, 1000 µl of the working reagent was added. To prepare the reagent blank, 10 µL of DDH20 was mixed with 1000 µL of working reagent. The absorbance of sample or standard against reagent blank was read at 546 nm after incubation for 5 min at 37 °C. Total cholesterol was calculated using the equation below;

$$Tc = \frac{\Delta \text{ Abs x [Std]}}{\Delta \text{Abstd}}$$

Where Δ Abs = change in absorbance of sample, Δ Abstd = change in absorbance of standard, [Std] = concentration of the standard.

2.4.2. Quantitative determination of total triglycerides

Using the triglyceride kit, the working reagent was prepared by reconstituting one vial of the enzyme reagent R2 with 10 ml of buffer R1. Serum was collected using standard sampling tubes and centrifuged at 3000 rpm for 10 min. To 10 µl of either sample or Standard, 1 ml of working reagent was added. The reagent blank only contained 1 ml of working reagent and one reagent blank per series was used. They were mixed thoroughly and then incubated at 37 °C for 5 minutes. Absorbance of sample or standard against reagent blank was read at 500 nm within 60 minutes. Total triglyceride was calculated using the equation below;

$$TG = \frac{\Delta \text{ Abs x [Std]}}{\Delta \text{Abstd}}$$

Where Δ Abs = change in absorbance of sample, Δ Abstd = change in absorbance of standard, [Std] = concentration of the standard.

2.4.3. Quantitative determination of high density lipoproteins (HDL)

For the HDL determination, LDL in samples (200 µl) was precipitated with LDL precipitant (500 µl). Incubation was allowed for 10 min at room temperature before centrifugation at 4000 rpm for 10 min. The supernatant was then carefully collected and assayed for cholesterol as described earlier (3.17.3.1).

2.4.4. Quantitative determination of low density lipoproteins (LDL) and very low density lipoproteins (VLDV)

The LDL and VLDL concentrations were derived from formula as described by Friedewald *et al*., 1972 [15].

$$\text{LDL Conc.} = \text{Total Cholesterol Conc} - (\text{Triglyceride Conc.}/5) - \text{HDL cholesterol Conc}$$

$$\text{VLDC Conc.} = \frac{Triglyceride\ Conc.}{5}$$

3. Results

3.1. Results of phytochemical analysis of *Zingiber officinale* and *Allium sativum* ethanol leaf extracts

Phytocompounds in *Zingiber officinale* were: Alkaloids, Tannins, Flavonoids, Steroids and terpenoids while those in *Allium sativum* were Alkaloids, Saponins, Flavonoids, and Glycosides [12].

3.2. Results of acute toxicity studies

The actual lethal doses of *Zingiber officinale, Allium sativum* and combination of the two were 8,660, 4,472, and 5,477 mg/kg body weight respectively [12].

Table 1 Results of 91st day cholesterol (CHO) concentration assay

Groups	Treatments given/kg body weight	Mean CHO ± SEM (mg/dL)	P-Value
1	Distilled water 10 ml	89.33 ± 0.68	-
2	*Zingiber officinale* 530 mg	79.33 ± 0.56	0.013071
3	*Allium sativum* 530 mg	77.67 ± 0.45	0.003637
4	Ratio of Z.:A. 2:8 (106 mg:424 mg)	75.00 ± 0.55	0.001264
5	Ratio of Z.:A. 4:6 (212 mg:318 mg)	76.50 ± 0.53	0.002364
6	Ratio of Z.:A. 5:5 (265 mg:265 mg)	78.33 ± 0.40	0.004276
7	Ratio of Z.:A. 6:4 (318 mg:212 mg)	84.17 ± 0.48	0.132281
8	Ratio of Z.:A. 8:2 (424 mg:106 mg)	80.50 ± 0.52	0.020682

Table 2 Results of 91st day TG concentration assay

Groups	Treatments given/kg body weight	Mean TG ± SEM (mg/dL)	P-Value
1	Distilled water 10 ml	65.83 ± 0.63	-
2	*Zingiber officinale* 530 mg	58.00 ± 0.85	0.033361
3	*Allium sativum* 530 mg	55.00 ± 0.59	0.002401
4	Ratio of Z.:A. 2:8 (106 mg:424 mg)	52.00 ± 0.53	0.000257
5	Ratio of Z.:A. 4:6 (212 mg:318 mg)	55.00 ± 0.66	0.003805
6	Ratio of Z.:A. 5:5 (265 mg:265 mg)	60.83 ± 0.69	0.114998
7	Ratio of Z.:A.6:4 (318 mg:212 mg)	60.00 ± 0.53	0.048722
8	Ratio of Z.:A. 8:2 (424 mg:106 mg)	59.17 ± 0.73	0.051798

Table 3 Results of 91st day HDL concentration assay

Groups	Treatments given/kg body weight	Mean HDL ± SEM (mg/dL)	P-Value
1	Distilled water 10 ml	38.00 ± 0.99	-
2	*Zingiber officinale* 530 mg	42.83 ± 0.74	0.141376
3	*Allium sativum* 530 mg	51.50 ± 0.56	0.000771

4	Ratio of Z.:A. 2:8 (106 mg:424 mg)	48.00 ± 1.00	0.024677
5	Ratio of Z.:A. 4:6 (212 mg:318 mg)	45.00 ± 0.83	0.058365
6	Ratio of Z.:A. 5:5 (265 mg:265 mg)	40.67 ± 0.52	0.343043
7	Ratio of Z.:A. 6:4 (318 mg:212 mg)	43.00 ± 0.55	0.094606
8	Ratio of Z.:A. 8:2 (424 mg:106 mg)	42.00 ± 0.68	0.202482

Table 4 Results of 91st day VLDL concentration assay

Groups	Treatments given/kg body weight	Mean VLDL ± SEM (mg/dL)	P-Value
1	Distilled water 10 ml	0	-
2	*Zingiber officinale* 530 mg	0	-
3	*Allium sativum* 530 mg	0	-
4	Ratio of Z.:A. 2:8 (106 mg:424 mg)	0	-
5	Ratio of Z.:A. 4:6 (212 mg:318 mg)	0	-
6	Ratio of Z.:A. 5:5 (265 mg:265 mg)	0	-
7	Ratio of Z.:A. 6:4 (318 mg:212 mg)	0	-
8	Ratio of Z.:A. 8:2 (424 mg:106 mg)	0	-

Table 5 Results of 91st day LDL concentration assay

Groups	Treatments given/kg body weight	Mean LDL ± SEM (mg/dL)	P-Value
1	Distilled water 10 ml	0	-
2	*Zingiber officinale* 530 mg	0	-
3	*Allium sativum* 530 mg	0	-
4	Ratio of Z.:A. 2:8 (106 mg:424 mg)	0	-
5	Ratio of Z.:A. 4:6 (212 mg:318 mg)	0	-
6	Ratio of Z.:A. 5:5 (265 mg:265 mg)	0	-
7	Ratio of Z.:A. 6:4 (318 mg:212 mg)	0	-
8	Ratio of Z.:A. 8:2 (424 mg:106 mg)	0	-

4. Discussion

Overall, both *Zingiber officinale* and *Allium sativum* exhibited desired effects on the lipid profile; they reduced the serum level of the bad cholesterols (total cholesterol and triglyceride), did not add to none existing bad cholesterols (LDL and VLDL) and increased the serum levels of the good cholesterol (HDL) when compared with the control group 1. However, the reduction in the bad cholesterols is more and of higher significance in the group administered only *Allium sativum.* The combination of the two herbs resulted to decrease in bad cholesterol and increased the good cholesterol. These were significant ($P < 0.05$) only when the proportion of *Allium sativum* was higher than that of *Zingiber officinale*. Specifically, in the total cholesterol assay, the serum level of cholesterol in the control group 1 was 89.33 ± 0.86 mg/dL. This was reduced to 79.33 ± 0.56 mg/dL ($P = 0.013071$) in group 2 which were treated with *Zingiber officinale* alone and to 77.67 ± 0.45 mg/dL ($P = 0.003637$) in group 3 which were treated with *Allium sativum* alone. The combinations cause reduction which became none significant from group 7 in which the serum level oh CHO became 84.17 ± 0.48 mg/dL ($P = 0.132281$). Triglyceride assay also followed the same trend but the reduction by the herbal combination became none significant from group 6 that had equal proportion (5:5). This gave a triglyceride serum level of 60.83 ±

0.69 mg/dL (P = 0.114998) compared to the control group 1 that indicated serum triglycerol level of 65.83 ± 0.63 mg/dL. In the case of HDL which is usually regarded as the good cholesterol, when compared with the control group, *Zingiber officinale* increased serum level of HDL none significantly from 38.00 ± 0.99 mg/Dl of the control group to 42.83 ± 0.74 mg/Dl (P = 0.141376). *Allium sativum* had a significant increase in HDL of 51.50 ± 0.56 mg/dl (P = 0.000771). LDL and VLDL which are also classified as bad cholesterol were not present in the control group nor in any of the treated groups.

This outcome was buttressed by an earlier study in which the hypocholesteremic activity of *Allium sativum* was tested by incorporation freeze-dried *Allium sativum* powder at 0.5, 1.0, 2.0 and 3.0% levels in an atherogenic diet fed to rats. The researchers observed that the group fed 2.0% *Allium sativum* powder had much lower serum cholesterol level than the one fed 3%. The increased levels of low density lipoproteins (LDL) and LDL-cholesterol in rats fed the atherogenic diet were partly reversed in rats receiving a supplement of 2% *Allium sativum* powder. On a cholesterol-containing diet, high density lipoprotein (HDL) and HDL-cholesterol levels were decreased. Inclusion of *Allium sativum* powder in the atherogenic diet enhanced the percentage of HDL whereas no change was observed in HDL cholesterol levels [16]. In a recent study that aimed at understanding the impact of *Allium sativum* on improving blood lipids using a meta-analysis, a literature search of the PubMed, EMBASE, and Cochrane Library databases was performed. The values of TC (SMD=–1.26, 95% CI, –1.86 to –0.66), low-density lipoprotein (LDL) (SMD=–1.07, 95% CI, –1.67 to –0.47), and high-density lipoprotein (HDL) (SMD=0.50, 95% CI, 0.06–0.94) after taking *Allium sativum* in the experimental group and the control group have statistical significance, while there was no significant difference of TG in the 2 groups (SMD=–0.16, 95% CI, –0.87–0.55). However, the result of HDL was reversed. The researchers concluded that *Allium sativum* can reduce the level of TC and LDL instead of HDL and TG, indicating the ability of anti-hyperlipidemia [17]. In another review, effect of *Zingiber officinale* supplementation on lipid profile in humans was evaluated. At least one of lipid profile components triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL-C), and high-density lipoprotein (HDL-C) was measured before and after *Zingiber officinale* consumption. According to the researchers, pooled data showed that *Zingiber officinale* intake reduced TC (SMD -0.44; 95% CI: -0.86, -0.02; p = 0.025) and TG (SMD -0.61; 95% CI: -1.14, -0.08; p = 0.024) levels significantly, but it has no significant effect on improving HDL-C (SMD 0.40; 95% CI: -0.01, 0.80; p = 0.057) and LDL-C (SMD -0.34; 95% CI: -0.81, 0.13; p = 0.153). *Zingiber officinale* supplementation decreased TG in obese and diabetic subjects more efficiently. In terms of *Zingiber officinale* dose, the result of meta-regression found to be significant only for TC, so that increasing daily doses of ginger reduces TC levels by (β: -0.67; 95% CI: -1.28, -0.07; p = 0.028). They concluded that *Zingiber officinale* could be considered as an effective lipid lowering nutraceuticals [18].

5. Conclusion

In this present study, it can be concluded that *Allium sativum* administered alone exhibited the greatest potentials in lowering bad cholesterol (TG, TC, LDL and VLDL) as well as increasing the good cholesterol (HDL) than *Zingiber officinale* or combination of the two herbs.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Maintenance and care of all animals were carried out in accordance with EU Directive 2010/63/EU for animal experiments. Guide for the care and use of Laboratory Animals, DHHS Publ. # (NIH 86-123) were strictly adhered to. Ethical approval was obtained from the Animal Ethical Committee of the Enugu State University of Science and Technology. There was additional approval by the Nnamdi Azikiwe University's Ethical Committee for the use of Laboratory Animals for Research Purposes; (Approval number is NAU/AREC/2023/00021).

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