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Ameliorative Effect of *Pleurotus ostreatus* on Lipid Levels and Atherogenic Indices in Hyperlipidemic Rats

N. L. Nwobi[1*], O. S. Usiobeigbe[2], R. O. Osaro[2] and J. C. Nwobi[3]

[1]Department of Chemical Pathology, Ben Carson School of Medicine, Babcock University, Ilishan Remo, Ogun State, Nigeria.
[2]Department of Medical Laboratory Science, School of Public and Allied Health, Babcock University, Ilishan Remo, Ogun State, Nigeria.
[3]Department of Biochemistry, Ben Carson School of Medicine, Babcock University, Ilishan Remo, Ogun State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. Author NLN designed the study and prepared the final manuscript. Author ROO followed the protocol and prepared the first draft of the manuscript. Authors OSU and JCN managed the analyses of the study and the literature search. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the effects of *Pleurotus ostreatus* on the lipid profile and atherogenic indices in Hyperlipidemic rats.
Study Design, Place and Duration of Study: This case-control study was done for 60 days between March and April, 2017 at the department of Medical Laboratory Science and Department of Chemical Pathology, Babcock University, Ogun State, Nigeria.
Methodology: Thirty male wistar rats weighing 117-130 g were divided randomly into 3 groups: Normolipidemic (NL) rats (fed with standard rodent chow), Hyperlipidemic (HL) rats (fed with

**Corresponding author: E-mail: lindanwobi@yahoo.ca;*

standard rodent chow + duck yolk and reused oil), Hyperlipidemic Treated (HL+T) rats (fed with standard rodent chow + duck yolk and reused oil + 5% *Pleurotus ostreatus* powder).
Changes in the animal body weights were measured in this study. Serum was obtained from fasting blood samples for the standard biochemical analyses of total cholesterol (TC), triglycerides (TG), High density lipoprotein cholesterol (HDL-C), creatinine, urea, Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST). Low density lipoprotein (LDL), very low density lipoprotein (VLDL), TC/HDL, LDL/HDL and Log (TG/HDL) ratios were calculated.
Results: The HL+T rats compared to HL rats had significantly reduced body weight, TC, TG, LDL, VLDL, TC/HDL, LDL/HDL and Log(TG/HDL) by 19.59%, 14.38%, 15.82%, 25.52%, 15.83%, 28.89%, 20.24% and 27.27% respectively ($p \leq 0.05$) but recorded no significant change in HDL-C ($p > 0.05$). Creatinine, urea, AST and ALT did not show any significant change in HL rats and HL+T rats ($p > 0.05$).
Conclusion: Treatment of hyperlipidemic male wistar rats with *Pleurotus ostreatus* reduced body weight, lipid levels (TC, TG, LDL, VLDL) and atherogenic indices (TC/HDL, LDL/HDL, Log (TG/HDL)) and appeared to have no detrimental effects on the liver and kidneys. These findings may provide insights and scientific basis for the promotion of the use of *Pleurotus ostreatus* in controlling hyperlipidemia and associated complications.

Keywords: Atherogenic indices; hyperlipidemia; lipid profile; oyster mushroom.

1. INTRODUCTION

Hyperlipideamia is a significant global health challenge that refers to increased levels of lipids and their transporting lipoproteins [1]. According to reports, the ratios of the lipids and lipoproteins clearly represent the connection between the atherogenic and protective lipoproteins and also appear to be better predictors of cardiovascular – related complications of hyperlipidaemia than each constituent of the lipid profile alone [1,2]. Although the use of drugs and lifestyle modification such as exercise have been the primary treatment for hyperlipidaemia, most of these drugs have their side effects and it is often difficult for patients to adhere to strict exercise regimen. It has been shown that dietary modification with natural plants may be a cornerstone in controlling hyperlipidaemia and its associated complications [3].

Pleurotus ostreatus, an oyster mushroom, is an edible natural plant that plays significant role in nutrition and health possibly owing to its richness in dietary fiber, proteins, microelements and various bio-active compounds such as gallic acid, protocatechuic acid, chlorogenic acid, naringenin, hesperetin and biochanin-A [4,5]. Apart from being low in fat content, *Pleurotus ostreatus,* is also rich in lovastatin – a lipid lowering agent that reduces the formation of atherosclerotic plaques [5]. This raises hope for the potential usefulness of this mushroom as an effective therapeutic agent for cardiovascular-related hyperlipidaemia complications which have been linked to more than one-third of global deaths [6].

The possible therapeutic quality of *Pleurotus ostreatus*, has not been given adequate consideration in terms of exploring its anti-hyperlipeademic potential particularly in developing countries where this plant is endemic. Moreover, given that there may be variation in the chemical content and actions of *Pleurotus ostreatus* based on the origin, extraction process, strain and cultivation conditions, data on the strain that is cultivated and eaten in South-west, Nigeria, are sparse [7].

The aim of this study was therefore, to evaluate the effect of *Pleurotus ostreatus* on the lipid profile and atherogenic indices as well as kidney and liver function indices in hyperlipidemic, male wistar rats inorder to validate its health benefit.

2. MATERIALS AND METHODS

2.1 Oyster Mushroom

Mature fruiting bodies of the oyster mushroom (*Pleurotus ostreatus*), were purchased from a local food market in Shagamu, South-West Nigeria and taken to the Agricultural Science Department of Babcock University for identification and authentication. The *Pleurotus ostreatus* samples were cleaned, washed, dried with hot air at 40ºC for 48hr and pulverized using a grinding mill.

2.2 Animals

30 male wistar rats, 117-130 g, were used for this study were procured from Babcock University Animal Facility, Ilishan Remo, Ogun

State and kept under standard conditions in ventilated polypropylene cages (50 x 40 x 30 cm) lined with wood shaving which were kept in a room that was maintained with temperature regulated at 25±1ºC and a 12 hours alternating light and dark cycle. The rats were acclimatised for 1 week and had ad libitum access to drinking water and standard rodent chow pellets which contained 14% crude protein, 7% Fats, 10% Crude fibre, 1% calcium and 0.35% phosphorous (Livestock Feed PLC, Lagos, Nigeria).

The rats were randomly divided into 3 groups (each group containing 10 rats each) based on what they were fed with: Normolipidemic (NL) rats (fed with standard rodent chow), Hyperlipidemic (HL) rats (fed with standard rodent chow + duck yolk and reused oil), Hyperlipidemic Treated (HL+T) rats (fed with standard rodent chow + duck yolk and reused oil + 5% *Pleurotus ostreatus* powder.

Hyperlipidemia was induced by orally administering a mixture of 1:1 ratio of duck yolk and reused cooking oil at 1% body weight according to the method of Sa'adah, et al. 2017 [6]. Each 100 g of duck egg yolk contained 1000 mg of cholesterol comprising 31.9% of saturated fatty acid, 53.9% of monounsaturated fatty acid and 17.1% of polyunsaturated fatty acid. The experiment lasted for 60 days.

2.3 Sample Collection and Biochemical Analysis

After 60 days, overnight fasting blood samples were obtained from the eye of the rats into sterile plain bottle, allowed to clot and centrifuged at 4000 rpm for 5 minutes to obtain serum which was stored frozen at −20ºC until used within 7 days for biochemical analysis. Serum levels of triglyceride (TG), total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C), Arspartate aminotransaminase (AST) and Alanine aminotransaminase (ALT) activities were measured based on standard methods as adapted in the appropriate Randox assay kits (Randox Laboratories Limited, UK) [8-11]. Creatinine and urea were measured by standard methods using an auto analyser with its accompanying reagents (Hitachi 7600-210; Hitachi, Tokyo, Japan). The LDL-C, VLDL-C, TC/HDL, LDL/HDL and LogTG/HDL ratios were calculated using standard formula [2,12].

2.4 Statistical Analysis

Statistical analysis was carried out on all the data using Statistical Package for Social Sciences (SPSS) software programme version 21.0 (SPSS Inc, Chicago, IL). The results were expressed as Mean ± SD. intergroup differences were analysed by one-way analysis of variance followed by Duncan post-hoc test. A $p \leq 0.05$ was considered statistically significant.

3. RESULTS

The HL rats showed 0.32% non-significant body weight increase compared to NL rats ($p > 0.05$) (Table 1). However, there was 19.59% significant decrease in body weight in HL + T rats compared with HL ($p < 0.05$) (Table 1). The TC, TG, LDL-C and VLDL levels significantly increased by 21.89%, 36.63%, 52.68% and 36.66% respectively in HL rats compared to levels in NL rats ($p < 0.05$) (Table 2). However, TC, TG, LDL-C and VLDL levels significantly decreased by 14.38%, 15.82%, 25.52% and 15.83% respectively in HL + T rats compared to HL rats ($p < 0.05$) (Table 2).

The ratios; TC/HDL, LDL/HDL and Log(TG/HDL) in HL rats, significantly increased by 80.00%, 40.47% and 60.60% respectively compared to NL rats ($p < 0.05$) but were significantly decreased by 28.89%, 20.24% and 27.27% respectively in HL + T rats compared to HL rats ($p<0.05$) (Table 2). The HDL-C levels decreased significantly by 15.09% in HL rats compared to levels in NL rats ($p<0.05$) but insignificantly increased by 4.46% in HL + T compared to HL rats ($p>0.05$) (Table 2). Creatinine, urea, AST and ALT did not show any significant difference among NL rats, HL rats and HL+T rats ($p > 0.05$) (Table 3).

Table 1. Effects of *Pleurotus ostreatus* treatment on the body weight of hyperlipidaemic rats

Variable	NL	HL	HL+T	F	P
Initial BW (g)	118.63±7.73	117.36±7.57	118.60±5.41	0.107	0.899
Final BW (g)	251.11±10.43	251.10±7.96	226.14±6.24[a,b]	30.534	0.000*
Weight gained (g)	133.31±15.80	133.74±14.13	107.54±9.53[a,b]	12.505	0.000*

** = Significant at p ≤ 0.05, [a] = Significantly different from NL, [b] = Significantly different from HL, BW = Body weight. NL = Normolipidaemic rats, HL = Hyperlipaedemic rats; HL + T = Hyperlipidemic rats treated with Pleurotus ostreatus*

Table 2. Effects of *Pleurotus ostreatus* treatment on lipid levels and atherogenic indices of hyperlipideamic rats

Variable	NL	HL	HL+T	F	P
TC(mg/dL)	141.47±4.53	172.45±4.68[a]	147.66±2.63[a,b]	163.639	0.000*
TG(mg/dL)	87.20±4.92	119.14±4.48[a]	100.29±4.83[a,b]	114.422	0.000*
HDL(mg/dL)	64.99±8.59	55.18±7.45[a]	57.64±6.72[a]	4.487	0.021*
LDL(mg/dL)	63.29±7.73	96.63±12.15[a]	72.74±4.43[a,b]	39.027	0.000*
VLDL(mg/dL)	17.44±0.98	23.83±0.89[a]	20.06±0.97[a,b]	114.422	0.000*
TC/HDL	2.22±0.39	3.18±0.43[a]	2.60±0.33[a,b]	11.321	0.000*
LDL/HDL	1.00±0.25	1.68±0.16[a]	I.34±0.22[a,b]	26.168	0.000*
Log(TG/HDL)	0.13±0.06	0.33±0.06 [a]	0.24±10 [a,b]	31.493	0.000*

*The results are expressed as mean±SD. * = Significant at p ≤ 0.05, [a] = Significantly different from NL, [b] = Significantly different from HL, TC = total cholesterol; TG = triglycerides; HDL = High-density lipoprotein cholesterol, LDL = low-density lipoprotein cholesterol, VLDL = very low density lipoprotein cholesterol*

Table 3. Effects of *Pleurotus ostreatus* treatment on liver and kidney function indices of hyperlipidaemic rats

Variable	NL	HL	HL+T	F	P
AST (U/L)	34.82±4.04	37.44±3.40	36.87±4.39	0.167	0.847
ALT (U/L)	34.82±4.04	38.61±3.11	34.12±6.09	2.766	0.081
Creatinine(mg/dL)	0.94±0.31	1.00±0.18	1.08±0.26	0.792	0.463
Urea(mg/dL)	19.46±1.11	21.69±2.60	20.72±2.69	2.454	0.105

*The results are expressed as mean±SD, * = Significant at p ≤ 0.05, AST = Aspartate aminotransferase, ALT = Alanine aminotransferase*

4. DISCUSSION

Hyperlipideamia is a significant risk factor for the development of cardiovascular complications which are common health issues responsible for more than 0ne-third of deaths globally [6].The observed reduced weight in hyperlipidemic rats treated with oyster mushroom (HL + T) is an indication that oyster mushroom can reduce obesity, which is considered a common risk factor for cardiovascular diseases [2,13]. The observed reduced TC, TG, LDL and VLDL level in HL + T may be because of the suppression of endogenous cholesterol biosynthesis owing to possible action by levostatin contained in mushroom which have been reported to have lipid-lowering effects [14]. This pattern of reduced lipid level may also be attributable to the availability of water soluble gel forming substances such as β -1, 3-D-glucan and pectin in mushroom which can bind to bile acids, inhibit cholesterol bile micelle formation and cholesterol reabsorption and increase faecal cholesterol excretion. Our observations are in line with other reports [15].

Although changes in the lipid profile may be considered as known risk factors for complications of hyperlipidaemia, changes in atherogenic indices such as ratios of TC/HDL, LDL/HDL and Log (TC/HDL) have been reported to be better predictors of cardiovascular diseases than the changes in any of the components of the lipid profile alone [6]. The observed high TC/HDL-C, LDL/HDL and Log (TG/HDL-C) ratios observed in HL rats compared to NL suggest greater cardiovascular risk owing to the imbalance between the cholesterol carried by atherogenic and protective lipoproteins. This may be because of an increase in the atherogenic component in the numerator, a decrease in the protective component of the denominator or a combination of both. However, the observed pattern of decrease in TC/HDL, LDL/HDL and Log (TG/HDL) in HL+T rats compared to HL rats may portray reduced risk of cardiovascular diseases and suggests that oyster mushroom may have potential in mitigating complications such as cardiovascular diseases in hyperlipidemic rats.

The indices of renal function (creatinine and urea levels) and that of hepatocellular injury (aspartate aminotransferase and alanine aminotransferase activities) showed no significant differences in NL, HL and HL+T rats suggesting that treatment with oyster mushroom has no adverse effects on kidney and liver functions [16,17]. However, it is advised that more toxicological assessments be done before justifying the safety of *Pleurotus ostreatus* for hyperlipidaemic patients.

5. CONCLUSION

This study provides evidence that administering *P.ostreatus* to hyperlipidemic wistar rats reduces body weight, constituents of lipid profile (TC, TG, LDL and VLDL) and atherogenic indices (TC/HDL, LDL/HDL and Log (TG/HDL) and appears to have no detrimental effects on the liver and kidneys. These findings provide insights and scientific basis for the promotion of the use of oyster mushroom for the control of hyperlipidaemia and associated cardiovascular-related complications.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All authors hereby declare that principles of laboratory animal care (NIH publication No.85-23, revised 1985) were followed as well as specific rational laws. The experimental design and protocol conformed with the guidelines approved by the Babcock University Health Research Ethics Committee, Babcock University, Nigeria.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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