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Research Article

High-fat diet from avocado oil as a possible risk factor for cardiovascular diseases

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Abstract

Background: One of the risk factors for the present global burden of metabolic disorders is poor dietary habits, particularly excessive consumption of high-fat diets. There have been debates over the contributions of plant high-fat diets to these disorders, particularly cardiovascular diseases. This study was aimed at investigating the effects of high-fat consumption from Avocado pear *Persea americana* on some nutritional parameters linked to cardiovascular diseases, using Wistar rats.
Methods: Fifteen adult Wistar rats, weighing between 60 and 70g, were grouped into three of five rats per group. Group one (control) was fed with normal rat diet, group two was fed with normal diet plus low quantity of fat diet (5g of avocado pear pulp), while group three was fed normal meal plus high quantity of fat diet (10g of avocado pear pulp). The treatment lasted 14 days during which the weights of the rats were measured every two days. The rats were then bled through the ocular veins. Electrolytes (sodium, potassium, bicarbonate and chloride) were measured using ion-selective electrodes, while the concentrations of fasting blood glucose and lipid profile (total cholesterol, high-density cholesterol, low-density cholesterol, very low-density cholesterol and triglycerides) were determined spectrophotometrically. The results were analysed using GraphPad Prism (version 10.6.1).
Results: The results showed that body weights increased progressively across all groups, with the highest gain observed in the group 3. There was no significant differences in the electrolyte concentrations of the three groups. Treated groups exhibited statistically significant decreases in blood glucose, total cholesterol, high-density cholesterol and low-density cholesterol, while very low-density lipoproteins and triglycerides significantly increased in treated rats when compared to control group ($p < 0.05$ each).
Conclusion: The results showed that plant high-fat diet induced hypertrglyceridemia in Wistar rats, with severity dependent on fat concentration. The findings suggest that heavy or prolonged intake of plant high-fat diets can predispose to metabolic disorders, particularly cardiovascular diseases, emphasizing the importance of dietary regulation in preventing cardiovascular and diabetic complications.

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1. Introduction

There is a global prevalence of metabolic disorders associated with high intake of dietary fat, including cardiovascular diseases and metabolic syndrome [1]. High-fat diets are known to induce, among other adverse effects, electrolyte imbalance, dyslipidemia, and oxidative stress, impairing normal physiological functions of the body [2]. Electrolytes play vital roles in maintenance of fluid balance, nerve impulse transmission, and muscle contraction. Therefore, electrolyte imbalance can lead to serious metabolic disorders, including cardiovascular and muscular dysfunctions, and impaired nerve conduction [3, 4]. However, due to its high fat content, avocado appears to offer protective effects that may extend to maintaining electrolyte stability [5]. Avocado oil supplementation was found to have reduced blood pressure and improved renal vasodilation in hypertensive rats, through water–electrolyte balance [6], while its leaf extract improved serum sodium and potassium levels in Wistar rats with acetaminophen-induced kidney injury, indicating nephroprotective and electrolyte-modulating properties [7].

One of the key risk factors contributing to metabolic disorders is poor dietary habits, particularly the excessive consumption of high-fat diets, especially those rich in saturated and trans-fats that cause elevated cholesterol levels, insulin resistance, and increased adiposity [8, 9]. Dietary fats are components of cell membranes and bioactive compounds, where they influence membrane fluidity and cellular functions, and modulate inflammations and immune responses [10–12]. Saturated fats have been implicated in impairment of insulin signalling, triggering of inflammatory pathway that impair metabolic regulation, and infiltration of adipose tissues by macrophages, causing release of pro-inflammatory cytokines that interfere with insulin action [13–15]. Impairment of insulin signalling reduces glucose uptake by tissues and increases hepatic gluconeogenesis which will lead to hyperglycemia [16, 17]. Furthermore, high-fat diets elevate circulating free fatty acids which are esterified into triglycerides in the liver, leading to diminished reverse cholesterol transport and increased development of fatty liver. However, unsaturated fatty acids have been consistently associated with improved lipid profiles, enhanced insulin sensitivity, and anti-inflammatory properties [18]. Avocado pears are known to contain, among other things, monounsaturated fatty acids – MUFAs [19].

Avocado pear *Persea americana* is a juicy fruit rich in monounsaturated fatty acids, fiber, and bioactive compounds [20]. Because of these contents, it exhibits antioxidant, anti-inflammatory, and lipid-lowering properties [21, 22]. The lipid-lowering property stemmed from the finding that its fatty acid contents are mainly unsaturated fatty acids (like many other plant fatty acids), given that the quality and composition of avocado fats differ significantly from the saturated fats typically implicated in metabolic disorders. Health benefits of avocado oil include reduction of cholesterol and improvement of heart health, reduction of cataract due to presence of antioxidant – lutein, enhancement of absorption of important lipid-soluble nutrients, alleviation of arthritic pains and antioxidant activities that ameliorate oxidative stress [23–25]. However, based on undocumented individual experiences, there have been debate on the possibility of high-fat diets, of plant origin, causing metabolic disorders, particularly cardiovascular diseases. This is because some individuals have complained that they usually experience sharp heart pain after heavy or prolonged consumption of avocado pears. So far, there have been conflicting experimental results on how avocado pear consumption affects the metabolism of dietary agents implicated in metabolic disorders, especially electrolytes, glucose and lipids. This study is taken to investigate the effects of plant high-fat diets from avocado pear on the said dietary agents using Wistar rats. This might discover the cause of such pains and advise clinicians appropriately on possible source of the said pain.

2. Materials and Methods

2.1. Avocado pear

Freshly ripped avocado pears were purchased from a local market in Enugu urban of Enugu State, Nigeria. The sample was identified and authenticated by Dr. C. Eze of the Department of Applied Biology and Biotechnology, Enugu State University of Science and Technology (ESUT), Enugu State, Nigeria.

2.2. Wistar rats

Fifteen (15) healthy male and female Wistar albino rats, weighing 60 – 70g, were obtained from the Animal House of College of Medicine, Enugu State University of Science and Technology, Enugu. They were subsequently housed in standard plastic cages at the Animal House and allowed to acclimatize for four (4) days under standard laboratory conditions (temperature 25 ± 2°C, 12-hour light/dark cycle). Throughout the acclimatization period, they were fed standard rat chow and clean water. All handling procedures followed international guidelines for animal care and use.

2.3. Experimental design

The edible pulp of the avocado pear was separated from the seed and peel. Exactly 500 g of the pulp was weighed using a digital weighing balance, blended with 1 litre of distilled water to obtain a homogeneous aqueous extract, and stored in a clean container under refrigeration (4°C) until needed for the experiment. The rats were randomly divided into three (3) groups (5 rats per group). Each rat in each group was uniquely identified using an indelible marker throughout the study. Group 1, which served as control, was fed normal rat chow and clean water only. Group 2 was fed normal rat chow mixed with 5g of avocado extract per day while group 3 was fed normal rat chow mixed with 10g of avocado extract per day. The 3 groups received their meals at the same time, three times a day for 14 days. The rats were then fasted overnight into the fifteenth day, and 5.0ml of blood collected from each rat via retro-orbital sinus puncture using sterile capillary tubes. About 2.0ml of the blood was dispensed into commercial fluoride container and mixed (for blood glucose estimation), while the remaining was put into grease-free glass test tube and allowed to clot and retract. The later was then centrifuged at 5000 rpm for 5 minutes and the resultant serum separated into a separation bottle (for electrolytes and lipid profile).

2.4. Weight measurement

The body weight of each rat in each group was measured every two days throughout the experimental period, to study the effects of each treatment on the rats. The mean weight and its standard deviation of each group per measurement day was recorded.

2.5. Biochemical analyses

Fasting blood glucose was determined using commercially prepared kit based on enzymatic method (Precision, by RDPL India). Serum electrolytes (sodium, potassium, bicarbonate and chloride) were estimated using ion-selective electrode method (Sensa Core, India), while lipid profiles were determined as earlier described [26]. All product procedures and precautions were properly and strictly followed for optimum results. All the analyses were in duplicates to ensure precision.

2.6. Data analysis

Data obtained from this study were analyzed using GraphPad Prism (version 10.6.1). Wilcoxon test was used to calculate the means and standard deviations in each group, while one-way analysis of variance was used to calculate the correlation between the values in different treatment groups at 95% confidence intervals. Statistical significance was set at $p \leq 0.05$.

3. Results

Table 1 shows the changes in mean body weights of the rats in each group. There were statistically significant changes, laterally and vertically, as the day increased. Laterally, there was significant positive correlation between the rats' body weights and treatment period. Vertically, there was significant positive correlation between the rats' body weights and quantity of avocado pear administered till the 8^{th} day. Thereafter, the correlation between the body weight and quantity of avocado pear became relative but non-significant.

Table 1: Weight changes (in grams) over the treatment period for all the groups

Group	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day 14	P-value	Remark
Group1	65.6 ± 1.8	72.4 ± 4.9	82.8 ± 4.3	92.6 ± 4.8	99.0 ± 7.0	107.0 ± 9.4	107.6 ± 10.3	<0.0001	Sig.
Group 2	67.0 ± 3.2	74.0 ± 3.2	84.2 ± 2.6	90.2 ± 4.8	99.2 ± 5.0	106.0 ± 6.7	101.0 ± 7.1	< 0.0001	Sig.
Group 3	85.8 ± 9.0	93.4 ± 8.5	100.8 ± 11.2	111.0 ± 12.7	113.8 ± 16.7	120.0 ± 19.4	124.2 ± 22.2	0.0001	Sig.
P-value	0.0001	0.0002	0.003	0.004	0.084	0.207	0.072		
Remark	Sig.	Sig.	Sig.	Sig.	NS	NS	NS		

Sig = Significant; NS = Non-significant

Table 2 shows the mean levels of all the parameters, electrolytes, blood sugar and lipid profile of the rats in each treatment group. There were no statistically significant changes in the serum levels of the electrolytes (sodium, potassium, bicarbonate and chloride), but blood glucose showed significant negative correlation with the quantity of avocado pear ($p = 0.030$). Likewise, there were negative correlations between the quantity of avocado pear and total cholesterol, high-density lipoprotein and low-density lipoprotein (p= 0.011, 0.022 and 0.001). However, both very low-density lipoprotein and triglycerides showed strong positive correlation with the quantity of avocado pear ($p = 0.001$ each).

Table 2: Mean ± SD electrolytes, blood glucose and lipid profiles in each treatment group

Parameter	Group 1 N = 5	Group 2 N = 5	Group 3 N = 5	P-values	Remark
Sodium (mmol/L)	142.44 ± 1.21	141.38 ± 0.52	142.40 ± 1.68	0.338	NS
Potassium (mmol/L)	5.02 ± 0.69	4.40 ± 0.17	4.70 ± 0.57	0.217	NS
Bicarbonate (mmol/L)	19.77 ± 1.27	19.61 ± 1.14	19.14 ± 1.25	0.705	NS
Chloride (mmol/L)	98.88 ± 1.29	99.13 ± 1.71	100.00 ± 0.22	0.359	NS
Blood Glucose (mmol/L)	4.38 ± 0.26	3.46 ± 0.64	3.96 ± 0.44	0.030	Sig.
TC (mg/dL)	93.6 ± 9.6	79.2 ± 13.3	71.0 ± 4.4	0.011	Sig.
HDL (mg/dL)	6.92 ± 0.88	5.62 ± 0.87	5.28 ± 0.76	0.022	Sig.
LDL (mg/dL)	77.24 ± 7.71	63.02 ± 11.43	49.96 ± 4.73	0.001	Sig.
VLDL (mg/dL)	9.44 ± 2.01	10.56 ± 1.85	15.76 ± 2.16	0.001	Sig.
TG (mg/dL)	47.2 ± 10.1	52.8 ± 9.3	78.8 ± 10.8	0.001	Sig.

TC = Total cholesterol; HDL = High-density lipoprotein; LDL = Low-density lipoprotein; VLDL = Very low-density lipoprotein; Sig = Significant; NS = Non-significant

4. Discussion

The results of this study showed that the weights of the rats significantly increased vertically and longitudinally. Vertically, there was positive correlation between the weights of the rats and quantity of avocado pulp administered. However, after 8^{th} day, there were no more significant increase as the quantity of the pulp increased. On the other hand, the significant changes occurred longitudinally till the 14^{th} day, implying that even if the quantity of avocado pulp is not increased, the weight will continue to increase as long as pulp is consumed. Diet is one those factors that influence bodyweight but which individuals have potential control. This result disagrees with earlier study [27] which reported that monounsaturated fatty acids from plant source was not associated with weight gain. Therefore, for the body weight to increase when avocado oil is administered means that the earlier study was not correct or that there is high amount of saturated fatty acid in avocado pear, given that only saturated fatty acids, of all types of fatty acids, are known to increase bodyweight [27, 28]. The results also revealed that all the electrolytes (sodium, potassium, bicarbonate, chloride) did not show statistically significant changes across the treatment groups. The findings are in agreement with earlier reports [29–31], which reported that avocado pear exerted a protective effect on renal electrolyte handling, supported stable electrolyte balance and reduced the risk of electrolyte disturbances, and preserved renal function and electrolyte homeostasis in experimental rats under oxidative stress. Furthermore, avocado oil supplementation was found to have reduced blood pressure and improved renal vasodilation in hypertensive rats, indirectly supporting water/electrolyte balance [6], while the leaf extract improved serum sodium and potassium levels in Wistar rats with acetaminophen-induced kidney injury [7], also indicating nephroprotective and electrolyte-sparing properties of avocado. The above actions have been attributed to the presence and activities of certain phytochemicals in avocado pear [32]. Furthermore, this study showed that avocado pear significantly reduced blood glucose concentration. This is in agreement with earlier study [33], which demonstrated that avocado supplementation improved glucose tolerance and reduced hyperglycemia in high-fat diet-induced diabetic rats. Subsequent study [7] suggested that the hypoglycemic effect of avocado can be attributed to the presence of some bioactive compounds like monounsaturated fatty acids and phytochemicals that can improve insulin sensitivity and glucose metabolism. This highlights the potential anti-diabetic and metabolic benefits of avocado extract, especially at moderate consumption.

This study further showed altered lipid metabolism in the rats fed with avocado pear pulp extract. While total cholesterol, high-density lipoproteins and low-density lipoproteins showed significant negative correlations with avocado dose, very low-density lipoprotein and triglyceride showed strong positive correlations with avocado dose. This result partially agrees with earlier study [23] which reported that avocado oil reduced low-density lipoprotein, but disagrees with part of the same study which also reported that avocado oil reduced very low-density lipoprotein and triglycerides. Avocado is a rich source of oleic acid, a monounsaturated fatty acid that improves lipid profile by modulating lipoprotein metabolism [19]. It also contains phytosterol which compete with dietary cholesterol for absorption from the intestine, thus lowering serum cholesterol level [34], and antioxidants like vitamin E and polyphenols which can reduce oxidative stress and inflammation known to exacerbate dyslipidemia [35]. Therefore, the lipoprotein-lowering potential of avocado is understandable. However, the finding from this study that avocado oil increased very low-density lipoprotein and triglyceride, which is in disagreement with previous studies, collaborates undocumented claims that some people experience heart pains after heavy consumption of avocado pears. Triglycerides is a known single risk factor for cardiovascular disease [36, 37], in addition to its involvement in pancreatitis, obesity and metabolic syndrome [38]. Again, the major function of very low-density lipoprotein is to transport other lipids from the liver to other tissues of the body [39]. Its high level in the blood has been implicated in the development of atherosclerosis [40], thus, increasing the risk of cardiovascular disease. Therefore, the increase in the levels of these two is a sure predisposing factor to cardiovascular disease. Thus, the possible cause of often-reported heart pain after heavy consumption of avocado pulp, can be possible increase in both very low-density lipoprotein and triglyceride. The disagreement between this study and the previous ones may stem from the actual compositions of different avocado pears. Avocado oils are known to contain about 12% saturated fatty acids [25]. It is possible that this percentage composition can vary from one region to another, and that when more oil is consumed, there is possibility of loading more saturated fats into the body. This is supported by the significant increases in the bodyweights of the rats as quantity of pulp consumed increased, and also as the duration of feeding increased. It is also possible that those who experienced heart pain already had other cardiovascular disease predisposing factors like obesity, diabetes and metabolic syndrome, factually or potentially. Thus, when saturated fat in the avocado is consumed, it will trigger or potentiate their effects on the heart. Therefore, it is dangerous to assume that plant oil cannot cause or exacerbate cardiovascular diseases; instead, it is necessary to know the percentage composition of saturated fatty acids in each plant oil before declaring it good for consumption. It is also necessary to individualize clinical and laboratory assessment before advising people on consumption of plant oils.

5. Conclusion

The results of this study showed that consumption of high-fat plant diet does not cause significant changes in serum electrolytes; it is nephron-protective and electrolyte-sparing. But, it caused significant decrease in blood sugar, total cholesterol, high-density cholesterol and low-density cholesterol. However, the significant increase in very low-density lipoproteins and triglycerides indicates that high consumption of high-fat plant diet can cause cardiovascular disorder, especially in individuals with other predisposing factors. It is therefore suggested that while the benefits of avocado oil are appreciated, care must be taken on the quantity and extent of its consumption.

Article Information

Disclaimer (Artificial Intelligence): The author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.), and text-to-image generators have been used during writing or editing of manuscripts.

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