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ORIGINAL ARTICLE

The Effect of Dietary Fat from Animal Sources on Prevalence of Obesity and Risk of Hepatic Diseases

Rawaa Salim Al-Mayyahi[1]*, Manal Nasser Al-Hayder[2], Nadeerah Falih Neamah[2]

1. Department of Clinical Laboratory Science, College of Pharmacy, University of Basrah, Basrah, Iraq
2. Department of Pharmacology and Toxicology, College of Pharmacy, University of Basrah, Basrah, Iraq

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**Corresponding author:*
Rawaa Salim Al-Mayyahi, PhD;
Department of Clinical Laboratory Science, College of Pharmacy, University of Basrah, Basrah, Iraq.
Tel: +96-47-708477937
Email: rawaa.salim@uobasrah.edu.iq

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ABSTRACT

Background: Obesity is a main risk factor for different health conditions including hepatic diseases. Previous studies suggested that the type and amount of dietary fat can contribute to such diseases. However, studies of dietary fats from different sources on obesity and its related diseases are reasonably sparse. The current work studied the impact of dietary fat of animal sources on weight gain and hepatic dysfunction in experimental rats.

Methods: Eighteen female albino rats were assigned to three equal groups of six rats. Animals were fed with standard food supplemented with olive oil and sheep tallow for one month. The activities of liver enzymes, lipid profile and hepatic histopathology were investigated.

Results: The sheep tallow could significantly increase the body weight compared to animals fed with standard diet and olive oil. Levels of liver enzymes were remarkably elevated in rats fed with sheep tallow revealing the hyperlipidemic activity of sheep tallow and its detrimental effects on hepatic tissue.

Conclusion: The current findings observed that fat from animal sources increased final body weight indicating the incidence of obesity with continuous feeding with fat of animal sources. The sheep tallow diet adversely affected lipid levels and liver enzymes and induced liver histopathological changes as a non-alcoholic fatty liver disease. In contrast, olive oil seems to be well metabolized in the liver reflecting its beneficial effects on health status.

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Introduction

Obesity can cause or aggravate several health issues with other health conditions or independently. Several studies investigated a link between obesity and the incidence of many health problems such as hepatic diseases, osteoarthritis and heart and respiratory diseases (1, 2). It was confirmed that longevity is negatively influenced by rising weight and obesity; while the risk of death within the last years has increased by 1% and 2% with every additional 0.45 kg weight gain among 30-42 years old and 50-62 years old people, respectively (3). The impact of dietary fat consumption on raising the incidence of obesity and its related diseases has been described before. Dietary fat is a significant component of the individual diet because it provides

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the energy and essential fatty acids of human body. It also has a vital role in vitamin absorption. In particular, the nutritional value of dietary fat relies on the constitution of fatty acids (4-6).

Dietary fats have different fatty acids; while most of them can be produced inside the body. However, humans do not have the enzymes necessary to synthesize the essential fatty acids; therefore, they must be acquired from the food (7). The control of lipid metabolism is differently affected by saturated and unsaturated fatty acids (8) as saturated fatty acids can negatively affect human health because they can elevate serum cholesterol levels and increase the risk of heart diseases (9). It was shown that saturated fatty acids adversely participate in the emergence of specific cancer types along with other effects; therefore, consuming less fat, particularly saturated fatty acids has been suggested (10). Monounsaturated fatty acids commonly have positive outcomes on the serum levels of lipids as they reduce low-density lipoprotein (LDL) oxidation. Monounsaturated fatty acids are mainly provided by plant oils such as olive oil (11, 12).

Depending on the ratio of saturated or unsaturated fatty acids, oils are classified as hard or soft oils. Plant oils (e.g. sunflower and olive oils) and animal fats are typically used as edible oils by Middle Eastern people. It was shown that the olive leaves have antioxidant, anti-atherosclerotic, hypotensive, anti-inflammatory and hypolipidemic effects (13, 14). Also, olive oil promotes antioxidants, suppresses oxidative stress and reduces septic pulmonary dysfunction in rats (15). However, several researchers have shed light on the meat fat content; that is a rich source of saturated fatty acids. The effect of this fatty acid was well established in increasing the risk of obesity and its associated diseases such as heart diseases and type 2diabetes mellitus because of its detrimental effects on plasma lipids particularly LDL-cholesterol and adipose tissue inflammation (16).

Several studies have compared sunflower oil and animal fat diets. Their findings showed that sunflower oil has hypolipidemic and hepatoprotective effects compared to beef tallow diets (17-19). The effect of olive oil diets and sheep tallow diets on body health still remains uncertain with a longstanding debate. Therefore, the present study investigated the impact of dietary fats from plant and animal sources on obesity incidence and liver dysfunction. Also, the consequences of using these two sources of fat on body weight, biochemical parameters, and hepatic histopathology has been analyzed.

Materials and Methods

Eighteen healthy female rats were between 36 and 42 days old weighed 215±26.2 g from the animal centre at the University of Basrah were enrolled. All animals were housed in proper cages covered by sawdust and received the typical rat pellet meal and tap water for two weeks before the experiments were started. Animals were adapted to the laboratory setting of a constant temperature (25°C) and regular 12 h of day/12 h of night. Rats were allocated into three groups (six animals in each group). The standard diet was fed to the untreated (control) group (20). The other two groups consisted of the olive oil group fed with olive oil diet and the sheep tallow group fed with sheep tallow diet. Dietary fat from plant and animal sources consisted of 20% fat (olive oil or sheep tallow) in addition to the similar components of the normal diet. The diets with standard and dietary fat were freshly prepared throughout the study. Olive oil was obtained from a supermarket and sheep tallow was obtained from local slaughterhouses from animals' adipose tissue extraction. The study was approved by the Ethics Committee of Basrah University/College of Pharmacy (Code Number: 055A in 17-11-2022).

Animal's body weight was assessed at the beginning of the study and before animal's sacrifice. After euthanasia, the entire liver was precisely removed and the relative weight of the liver was assessed with respect to the final weight of rats and presented as a percentage. The results of body weights and relative organs were recorded and statistically analysed. Samples of blood were taken from the animals by cardiac puncture in tubes without an anticoagulant. Blood samples were assessed for liver function enzymes including alkaline phosphatase (ALP), alanine aminotransferase (ALT) and aspartate aminotransferase (AST). Lipid concentration such as LDL, very low-density lipoprotein (VLDL), high-density lipoprotein (HDL), total cholesterol (TC) and triglycerides (TG) were also estimated. Commercial kits (BIO-RED, Thailand) were used to determine the concentration of LDL and VLDL by following the manufacturer's instructions and applying Friedewald's formula (21).

After 30 days, all animals were sacrificed and the entire liver was removed and fixed in 10% neutral formalin at room temperature. Liver tissues were prepared for histological examination by embedding in paraffin. The rotary microtome was used to cut the paraffin blocks and obtain sections of 5 µm in thickness. The obtained sections were stained by haematoxylin and eosin (H&E). The light microscope and digital camera were employed to capture images for histopathological analysis (22). The results were analysed by Prism statistical analysis software (San Diego, CA, USA; version 5.0) and all findings were presented as mean±standard error of the mean (SEM). ANOVA with post-hoc analysis were utilized for statistical analysis and a *p* value less than 0.05 was considered statistically significant.

Results

The initial body weight was identical across all groups. After 30 days of dietary treatment, mean body weight was determined to be 208.55 g for the rats fed with the standard diet, 212.16 g for animals nourished with the olive oil diet and 242.5 g for those received the sheep tallow diet (n=6 for all groups). Interestingly, rats with sheep tallow intake gained more weight significantly ($p<0.05$) compared to untreated group. There were no obvious variations between animals that received an olive oil diet and those that consumed a standard diet (Figure 1A). A significant difference was observed for the weight gain of liver ($p<0.001$) of those fed with sheep tallow versus the other two groups. However, no noticeable variation was visible in the liver weight of rats nourished with olive oil versus untreated rats (Figure 1B).

The liver enzyme activity of animals nourished with olive oil and with sheep tallow was presented in Figure 2 demonstrating that the activity of liver enzymes was significantly elevated ($p<0.001$) in rats fed with sheep tallow when compared to the control group (Figure 2). There was no significant difference between olive oil and control animals ($p>0.05$) as shown in Figure 2. The effect of various dietary fats including olive oil and sheep tallow on serum lipid profiles was shown in Figure 3. TC, TG, LDL, and VLDL levels were remarkably elevated in rats that received sheep tallow when compared with the control group ($p<0.05$). The mean of HDL significantly increased ($p<0.001$) in the olive oil group versus the control group (Figure 3).

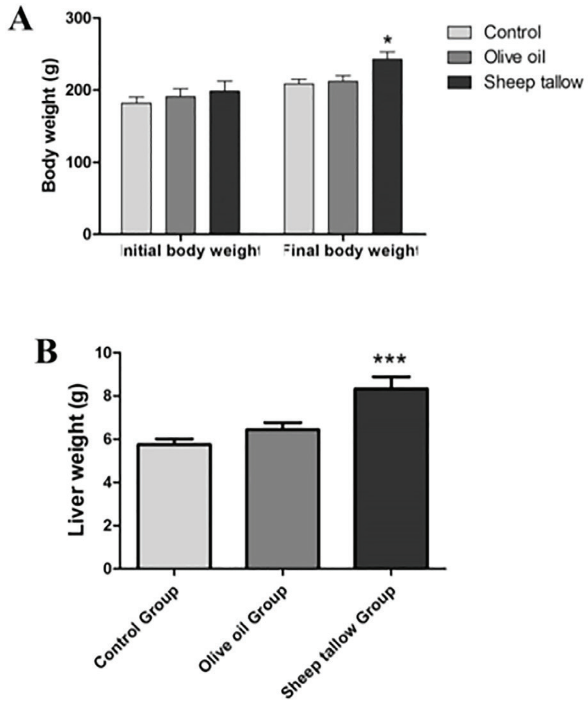

Figure 1: Animal weight gain after feeding with different types of dietary fats. (A) The animals' body weight (initial and final weights). (B) The liver weight of all treatment groups; * and *** represent the statistical significances at $p<0.05$ and $p<0.001$, respectively.

The histological study of the present work noted intact hepatocyte architecture of rats' liver fed with a standard diet (the control group, Figure 4A). Also, normal liver tissue was obvious in olive oil group (Figure 4B). The hepatic sections of sheep tallow group displayed morphological changes. The liver lobe showed localization of atypical hepatocytes, dilation of central vein and a ballooning degeneration of hepatocytes in sheep tallow group when compared with the control and olive oil diet groups (Figure 4C).

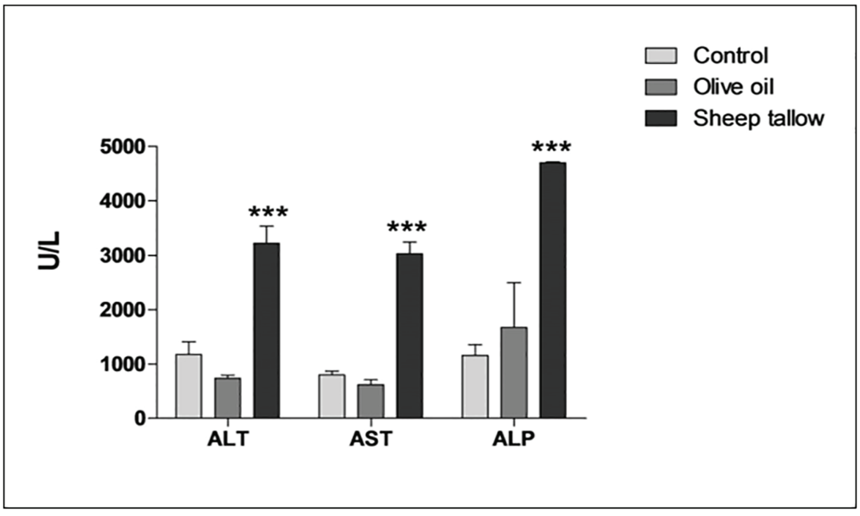

Figure 2: Level of liver enzymes in rats fed with different dietary fats. The graphs shows significant elevation in alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) across all treatment groups. *** represents the statistical significance at $p<0.001$.

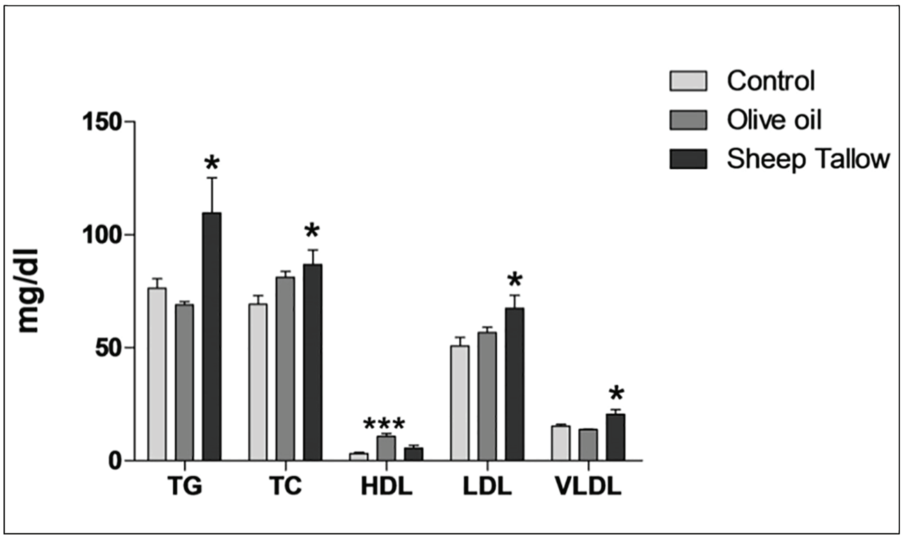

Figure 3: Dietary fat impact on lipid profile values illustrating a significant elevation in triglycerides (TG), total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoproteins (LDL) and very low-density lipoprotein (VLDL). * and *** represent the statistical significance at $p<0.05$ and $p<0.001$, respectively.

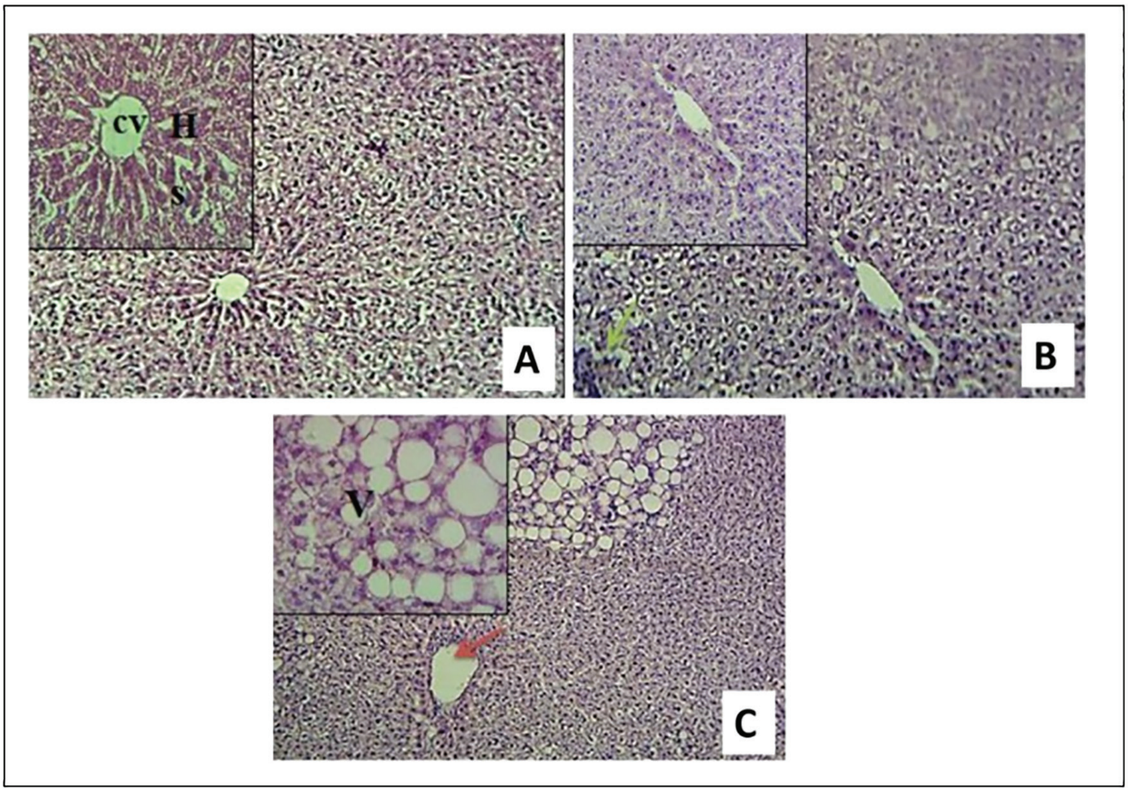

Figure 4: Dietary fat impact on hepatic histology. (A) The control group shows normal liver structure with normal hepatocytes (H), central vein (CV) and sinusoid (S). (B) Olive oil diet group demonstrate loss of normal structure of hepatocytes (green arrow). (C) The sheep diet-treated group display central vein dilation (red arrow) with hepatic ballooning degeneration of hepatocytes (V) (H&E, 100x and 400x magnifications).

Discussion

Obesity is a preeminent risk factor for many conditions including liver and heart diseases, type 2 diabetes mellitus, and malignancies (3). The impact of genetics to regulate body weight and metabolic processes of feeding in humans and animals was described before (23). However, the increase in global obesity in recent years cannot only belong to genetic factors (24). A growing food intake and a reduced energy use were shown to be linked with a sedentary lifestyle and to contribute in a wide manner to the recent rapid prevalence of obesity (25). Interestingly, dietary fat can contribute obesity and fat intake and is responsible for adiposity development. The dietary fat effect on adiposity and body weight was shown to be limited and in this context, different types of fat diets were studied in animal researches due to their similarities with human obesity (26).

Hence, the present work examined two different sources of dietary fats (plant origin versus animal origin) in experimental rats and revealed a significant increase in body and liver weight in rats fed with sheep tallow diet. This result showed that the increase in weight gain might not be related to the amount of dietary fat, indicating that different kinds of fats have critical impacts. In addition, the data suggested that the olive oil diet had beneficial outcomes when compared with the sheep tallow source since the olive oil group induced a lower body weight. Identically, it was shown that the type of fatty acids are considered a crucial indicator in weight gain and obesity development more than the amount of fat intake (27).

The edible oils produced by plants have many benefits for human health due to their abundance of unsaturated fatty acids (28). However, animal fats have detrimental effects on human health due to their high contents of saturated fatty acids. Continuous intake of saturated fatty acids are implicated in several health issues such as obesity, heart diseases and hypertension (29). In contrast, the important role of saturated fatty acids was recently demonstrated in several diseases such as reducing the severity of pancreatitis in humans and the metastatic capacity of cancer cells (30). However, there is some debate on this matter since several studies have observed no obvious difference in body weight of the animals fed with various fatty acids (31). Similarly, Al-Hayder *et al.* showed a noticeable rise in the final weight of those nourished with an animal tallow diet (17).

Our current results demonstrated that level of liver enzymes significantly increased in rats treated with sheep tallow diet. A continuous elevation in liver enzymes may cause non-alcoholic fatty liver disease (NAFLD) and other liver conditions. Moreover, the present finding denoted to a high serum lipid value in TC, TG, LDL and VLDL among those received sheep tallow diet when compared to the normal and olive oil diets. Most interestingly, the elevated concentration of lipid profile was correlated with atherosclerosis; a LDL transfers cholesterol from the liver to arterial tissues. A high level of LDL can lead to cholesterol accumulation inside the wall of the aorta and arteries and cause the narrowing of their diameter. Therefore, the elevation of LDL increases the risk of cardiovascular diseases. In contrast, the present finding showed that HDL level increased in rats treated with olive oil diet in comparison to the standard and sheep tallow groups. This result is in agreement with a previous study showing that HDL value increased in animals fed with an olive oil-enriched diet (32). HDL helps recycling of cholesterol level by transporting them to the hepatic tissue (33, 34).

A previous study observed that using a plant source of dietary fat (coconut oil) containing monounsaturated and polyunsaturated fatty acids was useful in lowering the concentration of lipid profile. This study was performed in Sri Lanka due to the high prevalence of cardiovascular diseases and because coconut oil is commonly used as a main source of dietary fat (35). A meta-analysis study on diabetic individuals revealed that a diet with monounsaturated fatty acids decreased lipid levels. Findings from this study indicated that a dietary fat enriched in monounsaturated fatty acids had beneficial impacts by decreasing adiposity and enhancing reduced lipid profile (36).

The most concerning result of this current study was the hepatic histological alteration particularly the observation of hepatocellular ballooning. As expected, there was a high correlation between serum liver enzyme elevation and liver histological alterations. Hence, hepatocellular ballooning is a common histological feature of NAFLD (37, 38). However, strong arguments might arise about hepatocellular ballooning in NAFLD diagnosis. Therefore, immunohistochemical analysis using different markers including loss of cytokeratin 8/18 expression in NAFLD diagnosis is critical and highly recommended in future works. The diagnostic features of NAFLD still need more improvement. NAFLD is strongly prevalent and highly associated with being overweight. The tremendous increase in obesity in the last years resulted in a rising incidence of hepatic disorders particularly in the developed countries. Due to the principal role of obesity in the aetiology of NAFLD, it can be predicted that loss of weight is an efficient treatment for NAFLD. Several researches have studied the impacts of weight reduction on NAFLD. They have observed good improvements in biochemical and histological analyses of hepatic diseases linked with obesity after weight loss (39, 40).

Conclusion

The present data revealed that fat from animal sources increased final body weight gain in favor of obesity. The sheep tallow could adversely affect lipid profile and liver enzymes and could develop into NAFLD. In contrast, the olive oil seems to be well metabolized in the liver with positive impact on health status. The detrimental effects of a fat diet in favour of obesity and its associated diseases might be related to its amount.

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Authors' Contribution

RSA wrote and drafted the manuscript. MNA designed the study and conducted the methodology. RSA and NFN performed analysed and interpreted the results. All authors have reviewed the manuscript.

Conflict of Interest

None declared.

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