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# HEPATIC AND ADIPOSE TISSUE ALTERATIONS INDUCED BY OLIVE OIL, COCONUT OIL, AND BUTTER IN ALBINO RATS

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**Abstract**
*Different classes of fatty acids appear to have different effects on body fat increase. Consequently, a need exists to evaluate the effects of various fatty acid classes on body composition and body fat distribution. Based on the above rationale, a study was designed to evaluate the biological effects of conventional olive oil, coconut oil and butter for comparisoneffects of fatty acids content of oils and butter on adipose liver tissue and serum lipid profile. For this purpose, forty rats, (20male and 20 female) fed on standard diet for one week as adaptation,after that scarified 10 rats as baseline group and distributed 30 rats to three groups (each 5 rat male and 5 female). Group (A) fed standard diet contain 10% olive oil, group (B) fed standard diet contain 10% coconut oil and group (C) fed standard diet contain 10% butter fat for four weeks.* ***Results*** *showed that coconut oil was the highest of saturated fatty acid. Femalesweremore affected thanmales in lipid profile and relative weight of liver and heart. In addition the microscopically examination for liver of rats fed different fat includedbaselinegroup showedhistopathological alteration. Conclusion, serum cholesterol concentration, saturated fatty acid (SFA) is generally considered to be hypercholesterolemic, whereas monounsaturated fatty acids are thought to be neutral or mildly hypocholesterolemic, while poly unsaturated fatty acid (PUFA) are hypocholesterolemic. Categorizing dietary fatty acids according to degree of saturation has been useful in developing dietary recommendations, although individual fatty acids within the same saturation category can have very different and specific effects on cholesterol metabolism.*

**Keywords:** Fatty acid, coconut oil, olive oil, butter fat, rats, lipid profile

## Introduction:

Nutrients regulate cellular functions at multiple levels through modulation of transcription, translation and activity of various enzymes. Fatty acids, especially polyunsaturated fatty acids (PUFA), modulate abundance and activity of key transcription factors such as sterol regulatory element binding proteins and peroxisome proliferator-activated receptors g (PPARg) to regulate adipose tissue function **(Al-Hasani and Joost 2005).** Recently, research shows that the total amount of fat in the diet isn't really linked with weight or disease. While that really matters is the type of fat and the total calories in the diet **[(Menteet al., 2009 and Mozaffarian, et al., 2011)]. RH & SS, (1991)** who was suggested an appreciable reduction in saturated fatty acids (SFA) from present levels of intake in most western countries to reducing coronary

heart disease (CHD). A major justification for this recommendation is the association between SFA and total and low density lipoprotein (LDL) cholesterol. Despite the clear demonstration that stearic acid (C18: O) has a negligible effect on total and LDL cholesterol **(Bonanome and Grundy, 1988),** therecommendations have not attempted to distinguish between individual SFA. In view of potentially undesirable effects of high intakes of n-6 polyunsaturated fatty acids (PUFA) **(Sheherd, et al., 1978; Mattson, and. Grundy. 1985 and Jackson, et al., 1984),** which are commonly used to replace SFA, it seems important to establish more precisely the effects of individual SFA on lipids and lipoproteins and also to compare the effects of widely used for fats with varying proportions of saturated fatty acids. The early studies and apparently contradictory results of **Keys, et al., (1965) and Hegstedet al., (1965)** regarding the hypercholesterolemic effect of various saturated fatty acids.While**Denke, & Grundy,(1992), and Zock, et al.,(1994)** who studied that the cholesterol-raising from three saturated fatty acids, whichappear the effect of myristic acid is most marked then palmitic acid greater than lauric acid.

Butter has appreciable amounts of butyric acid, used by the colon as an energy source. This fatty acid is also a known anti-carcinogen. Lauric acid, a medium chain fatty acid, is a potent antimicrobial and antifungal substance. Butter also contains conjugated linoleic acid (CLA) which gives excellent protection against cancer.Butter is rich in trace minerals, especially selenium, a powerful antioxidant. Ounce for ounce, butter has more selenium per gram than either whole wheat or garlic. Butter also supplies iodine, needed by the thyroid

gland (as well as vitamin A, also needed by the thyroid gland).Butter is a rich source of easily absorbed vitamin A, needed for a wide range of functions in the body, from maintaining good vision, to keeping the endocrine system in top shape. Butter also contains all the other fat-soluble vitamins (E, K, and D) **(Byrnes, 2001).**

Coconut oil has >90% saturated fatty acids, hence is less attractive to consumers. Also, it is rich in short and medium chain fatty acids (MCTs). Shorter chain length allows fatty acids to be metabolized without use of the carnitine transport system **(Gopala -Krishna, et al., 2010).**MCTs have a different pattern of absorption and utilization than long chain triglycerides (LCTs) that make up 97 percent of dietary fats. MCTs are transported into the mitachondria independent of the carnitine shuttle, which is necessary for LCT mitochondrial absorption. Oxidation of MCTs provides 8.3 calories per gram, while LCTs provides 9.2 calories per gram. They go straight to the liver from the digestive tract, where they are used as quick source energy or turned into so-called ketone bodies, which can have therapeutic effects on brain disorders like epilepsy and

Alzheimer's **(Heydnger and Nakhasi, (1996).**

Olive oil, the main fatty component is characterized by consisting of monounsaturated fatty acids as well as by its elevated content in antioxidant agents. This oil exhibits numerous biological functions which are beneficial for the state of health. Olive oil is able to scavenge free radicals and afford an adequate protection against peroxidation. On the other hand, several investigations have suggested that olive oil can be

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beneficial in inflammatory and autoimmune diseases, such as rheumatoid arthritis. Finally, it has been demonstrated that a diet rich in olive oil is associated with a high percentage of gastric ulcer healing and affords a higher resistance against non-steroidal anti-inflammatory drugs-induced gastric ulcer genesis **(La Lastra, et al., 2001).**

The experiment was designed to compare the effects of the types and sources of dietary fats on adipose Liver tissueand lipid profile in rats.

## I. Material and Methods:

**Materials:**

**Chemicals**: DL-methionine, choline chloride, vitamins, and minerals, required were obtained from ElGomhorya Company for chemicals and Drugs, Cairo, Egypt.

Skimmed milk, corn starch, Olive oil, coconut oil and butter required for preparing experimental diets were purchased from local market, Cairo, Egypt.

**Experimental animals:**forty healthy adult male and female albino rats "Sprague Dawley strain" weighing (100 ± 10g.) were obtained from vaccine and immunity organization Helwan Farm, Cairo, Egypt.

**Kits** for biochemical analysis were obtained from El-Gomhorya Company for chemicals and drugs, Cairo, Egypt.

**Diets,** standard diet was prepared from fine ingredients per 100g. The diet had the following composition: sunflower oil 10%; salt mixture 4% according to **Hegestedet al, (1941),** vitamin mixture 1% according to **Campbell (1961),** choline chloride 0.2%, DL-methionine 0.3% and protein was added 12% from skimmed milk according to **Reeves et al., (1993)**.

**Experimental design:**

Forty healthy adult albino rats "Sprague Dawley strain" weighing (100± 10g.) Food and water were administrated ad-libitum during the period of experiment (**4 weeks)** and was approved by the experiments animal unit- National Nutrition Institute.

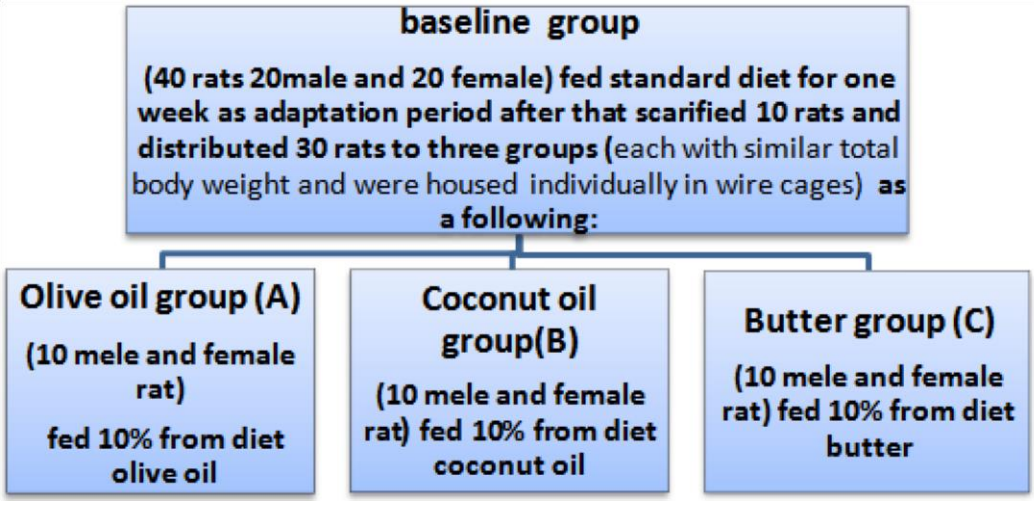

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**Figure 1** Experimental design

At the end of experiment, the animals were fasted overnight, and then sacrificed after anesthesia and blood samples were taken from hepatic portal vein. The rest of the blood were left in centrifuge tube at room temperature for 15 min. sample and then centrifuged at 4000 r.p.m. for 15 minutes. Serum was separated in plastic tube at -20° C until analysis. Heart, liver, and kidney removed, washed in saline (NaCl) solution 0.9%, and dried with filter paper then weighed. Part of liver was fixed in formalin solution 10% then subjected to histological examination. Other part of liver storage at-20° C until analysis.

**Biological Parameters:**

- **Body weight gain (BWG):** Animals were weighed twice a week. At the end of experiment calculated for them as a mean and standard error for each group. Body weight gain= final body weight – initial body weight
- **Feed efficiency ratio (FER):** Calculated according to **Eggum et al., (1973)** as follows: Feed efficiency ratio = Body weight / Feed intake
- **Relative weight organs (RWO):** Calculated as follows:

Relative organs = Organ weight / Final body weight X100

**Chemical analysis:**

Gas Chromatography Mass Spectrometry (GC Mass) was used to analyze the fatty acid content of olive oil, coconut oil and butter fat according to **(AOAC 2001)**.

**Biochemical analysis**

In liver tissue determined, T. lipid, triglyceride (TG) according to **Bligh, and Dyer (1959)** and Malondialdehyde (MDA) measured colourimetrically according to the method of **Uchiyama &Mihara (1978).** In serum, total triglycerides (TG) and high-density lipoprotein (HDL) were measured using commercially available kits according to**Wahlefeld, (1974) and Stein, (1986).**Serum total cholesterol (TC) was estimated using a spectrophotometer **Stein, (1986).** Low-density lipoprotein (LDL) was calculated from TC, HDL and TG values by an equation according to **Friedewaldet al., (1972):** LDL =TC _ HDL _TG/5

**Statistical analysis:**

Statistical analysis of the results by using computer program **(SPSS),** Independent F-test and one-way analysis of variance (ANOVA) were used, the difference was considered significant at P-value < 0.05 **(Zar, 1984)**

**Results and discussion**

Dietary fats are found in both plant and animal foods. Fats supply the bodywith calories and essential fatty acids, and help in the absorption of the fat-soluble vitamins A, D, E, and K.The fatty acid percent composition of tested oils and butter fat were as a relative percentage.

**Table (1) Fatty acid profile for olive oil, coconut oil and butter**

| Saturation | Fatty acid | Olive oil | Coconut oil | Butter fat |
|---|---|---|---|---|

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| | | | | |
|---|---|---|---|---|
| **Saturated fatty acid** | Butyric acid | --- | --- | 2.27 |
| | Valeric acid | --- | --- | 0.02 |
| | Capric acid | --- | 0.53 | 1.54 |
| | Caprylic acid | ---- | 7.78 | 0.91 |
| | Caproic acid | ---- | 7.19 | 1.97 |
| | Nonanoic acid | --- | 0.01 | 0.01 |
| | Undecanoic acid | --- | 0.03 | -- |
| | Lauric acid | 0.02 | 35.25 | 2.66 |
| | Tridecanoic acid | | 0.03 | 0.07 |
| | Myristic acid | 0.04 | 19.17 | 13.65 |
| | Pentadecanoic acid | --- | 0.02 | 2.29 |
| | Palmitic acid | 18.21 | 12.6 | 34.26 |
| | Margaric acid | 0.03 | 0.01 | 1.42 |
| | Stearic acid | 0.20 | 3.99 | 18.36 |
| | Arachidic acid | 0.22 | 0.09 | 0.23 |
| | Heneicosanoic acid | ---- | --- | 0.11 |
| | Behenic acid | 0.04 | 0.03 | 0.13 |
| | Tricosanoic acid | --- | 0.01 | 0.08 |
| | Lignoceric acid | 0.04 | 0.03 | 0.09 |
| **Mono-unsaturated fatty acid** | 4 Decenoic acid | --- | --- | --- |
| | PalmitOleic acid | 1.33 | 0.06 | 1.08 |
| | Oleic acid | 66.70 | 10.54 | 16.42 |
| | 10 Nonadecenoic acid | -- | -- | 0.23 |
| | 11-Eicosenoic acid | 0.11 | 0.06 | 0.08 |
| **poly-unsaturated fatty acid** | Linoleic acid | 12.59 | 2.58 | 1.79 |
| | Linolenic acid | 0.47 | 0.01 | 0.07 |
| | Linoelaidic acid | --- | -- | -- |
| | Arachidonic acid | --- | -- | -- |
| Total saturated fatty acid | | 18.80 | 86.75 | 80.33 |
| Total unsaturated fatty acid | | 81.20 | 13.25 | 19.67 |

The result of analysis showed that the percentage of the total SFA ranged from 18.8% for olive oil to 86.75 and 80.33% for coconut oil and butter fat respectively, with the predominant presence of palmetic acid (C16:0) for olive oil; with the predominant presence of lauric acid (C12:0) followed by Myristic acid (C14:0)

and palmetic acid (C16:0) for coconut oil; and with the predominant presence of palmitic acid(C16:0) followed by stearic acid (C18:0) and myrestic acid (C14:0).

Table (1) clarified butter differentiated by the presence of Butyric acid, and increase in caproic acid, palmitic acid and Stearic acid than other fat. Lauric acid found in coconut oil (35.25% from total fatty acid) follows myristic acid (19.17 %) then caprylic acid and capric acid. The total content of unsaturated fatty acid (USFA) was the highest in olive oil (81.2%) and the lowest content was (13.25 %) for coconut oil but the moderate in butter fat. Olive oil Marked by Oleic acid follows linoleic acid.

Regarding to table (1) showed that the results disagreed with **Gunstone, (1986)** who estimated fatty acids in each of butter, coconut oil and olive oil, who showedthat increase in butyric acid, capric acid, caproic acid and lauric acid in butter than the present results in table (1),whilemyristic acid, palmitic acid and stearic acid had decreased. Also, he showed higher in Mono-unsaturated fatty acid and poly-unsaturated fatty acid than finding in the present investigation. **Gunstone, (1986)** explained that coconut oil had 90% saturated fatty acids compared with data in table (1) which was 86.75. In additionhe foundthat olive oil had increased in unsaturated fatty acid compare to data in table (1). Data in the same table was confirms a previous study by **Nakbiet al., (2010)** who evaluated fatty acid profile of olive oil (SFA 17.28 ± 0.22, MUFA 66.20 ± 2.34 and PUFA 14.99 ± 0.94).

Butyric acid (originally isolate in butter) is known to have varying degrees of antimicrobial activity. This fatty acid is absorbed directly into the colon and serves as energy in that way. Butyric acid has been shown to have anti-tumor properties. Butyric acid is used to treat cancer **(Lim Sylianco, 1987).**

**Mensink, &Katan (1990)** said that the major sourcesof palmitic acid are butter fat, and two vegetable oils, coconut oil and palm kernel oil; the latter two also contain large amounts of lauric acid. While the palm oil, (another vegetable oil) is high content saturated fatty acids, is low in myristic acid and high in palmitic acid.Myristic acid has been reported to be the strongest serum cholesterol elevating fatty acid **(Hegstedet al., 1965). Mensink, et al, (2003)** reported that Lauric acid is effective in treating viral infections and raises HDL.

Meta-analyses of dietary trials that employed commercially available fats indicate that myristic acid might be four to six times more cholesterolemic than palmitic acid **(Mensink and Katan, 1992).** Some recent studies also suggest that palmitic acid lowers cholesterol relative to a mixture of lauric acid and myristic acid **(Sundramet al., 1991 and Ng TKW, et al., 1992).** However, others have found that palmitic acid strongly increases cholesterol levels [**Bonanome& Grundy (1988); Denke, & Grundy (1992) and Nestelet al.,**
**(1992)].**

Initially, stearic acid, a saturated fatty acid, was considered to have no effect on serum cholesterol **(Keys et al., 1965 and Grande et al., 1970),** but**Bonanomeet al., (1992)**reported it has been lower serum cholesterol**. Kris-Ethertonet al., (1993)** showed that stearic acid has unique effects on plasma total cholesterol levels compared with other long-chain saturated fatty acids. Author also has shown that linoleic

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acid has a more potent hypocholesterolemic effect than oleic acid and does not affect HDL cholesterol levels or HDL composition.

Monounsaturated fatty acid effects were first considered as being neutral with regard to serum cholesterol **(Keys, et al., 1957);** however the work of **Grundy, (1989)** has shown that monounsaturated fatty acids are as effective as polyunsaturated fatty acids in lowering serum cholesterol.

The early classical studies **(Ahrens, et al., 1957 and Keys, et al, 1957)** indicated diets containing high levels of polyunsaturated fatty acids were effective in lowering serum cholesterol levels; however studies in recent years have demonstrated that dietary polyunsaturated fatty acids also lower.

Olive oil is far higher in monounsaturated fatty acids than any other fat or oil. Unsaturated fatty acids are thought to be better for health than saturated fatty acids, with monounsaturated ones being the best **(Boyle & Anderson 2007).**

**Table (2)** Relative weight of some organs, weight Change and feed efficiency during experimental feeding on different fat diets (mean ± SE)

| Sample / Parameter | Sex | Baseline group | Olive oil group | Coconut oil group | Butter group | P value |
|---|---|---|---|---|---|---|
| Relative weight of Liver | Male | 2.8 ± 0.46 | 3.2 ± 0.37 | 3.9 ± 0.48 | 3.4 ± 0.3 | 0.381 |
| | Female | 2.97 ± 0.14 | 4.1 ± 0.39 | 3.92 ± 0.13 | 4.05 ±0.09 | 0.023* |
| **P valu e** | | 0.351 | 0.056 | 0.451 | 0.049* | --- |
| Relative weight of Kidney | Male | 0.6 ±0.05 | 0.86 ±0.1 | 0.8 ±0.07 | 0.72 ±0.05 | 0.254 |
| | Female | 0.67±0.09 | 0.86±0.07 | 0.75±0.06 | 0.8±0.03 | 0.242 |
| **P valu e** | | 0.281 | 0.5 | 0.309 | 0.131 | -- |
| Relative weight of Heart | Male | 0.5±0.1 | 0.26±0.02 | 0.38±0.03 | 0.3±0.01 | 0.008* |
| | Female | 0.43±0.03 | 0.34±0.02 | 0.3±0.04 | 0.34±0.04 | 0.173 |
| **P valu e** | | 0.281 | 0.024* | 0.096 | 0.173 | -- |
| BWG | | Male | 30.4±7.6 | 25.2±3.3 | 34.4±5.3 | 0.535 |
| | F | emale | 28.5±4.9 | 29.5±4.6 | 39.0±1.0 | 0.176 |
| **P value** | | | 0.42 | 0.24 | 0.22 | --- |
| FER | | Male | 8.42±0.96 | 8.98±0.54 | 9.2±0.99 | 0.806 |
| | F | emale | 7.6±0.5 | 8.55±0.4 | 9.5±0.3 | 0.023* |
| **P value** | | | 0.242 | 0.266 | 0.382 | -- |

*Significant is P< 0.05

Table (2) clarified that relative liver weight of all female groups fed on different fat diets higher than in male groups. This increase wasno significant differences compare all groupexcept rat fed on butter fat had significantly between male and female. While within female groups fed all type fat showed significantly differences. Coconut oil as a source fat had the highest relative weight of liver in female groups but it was

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the lowest in male. Olive oil was contrary to theresult of coconut oil. The weight of liver increased significantly may be due to accumulation of fat in the cells of the liver due to high level of cholesterol and other fats in the blood, its uptake by HDL and return to the liver to metabolism and excretion with urine and fecal. The results go in the same line with that reported by **Jennings et al., (1988**) who observed that 1% cholesterol feeding increased total liver lipids almost three folds and liver cholesterol concentration almost 10-folds which significantly increase in liver weight. In a study by **Ahmad et al.,(2007)** the weight of liver was significantly higher in rats given 7% fish oil and soybean oil for 7 weeks. Similarly **Astorg and Levillain(1979)** found that erucic acid induce an increase in liver weight. **Imofidon and Okunrobo(2012)** showed that the increase in liver weights of rats that received a 10% palm and groundnut oil supplemented diet was accompanied with a mild inflammation in the liver. **Kritchevskyet al.,(1983)** detected that rats were fed on 14% cocoa butter for 21 days had a lower relative liver weight compared to those rats that received the same percent of corn, and palm kernel oil.

Regarding to data in table (2) found that increased in relative weight of kidney in all groups fed on diet containing olive and coconut oil and better compare to baseline group while no significant differenceswithin this groups or between male and female. Results in present study in accordance with study by**Morisseyet al., (1986)** showed that there were no pathological abnormalities due to the addition of cocoa butter up to 30% for 90 days. This may explain the reason why there is no difference in terms of the kidney weights in this study. Olive oil showed nearest results of relative kidney weightfor male and female rats. Butter observed higher relative kidney weight in female than male rats while coconut oil showed converse with butter results.

Results of relative heart weight showed a significant difference for male groups but female no significantly. Olive oil groupexplaineda significant difference between female and male groups. These results in agreement with **Alaamet al., (2012)** who observed no significant differences in hearts relative weights among all the tested rat groups and control rats.

Findings of this study noticed that gradual increase in body weight of all the animals with advancing the experimental period. It was cleared that the growth performance of rats was not significantly ($p<0.05$) affected by the dietary (olive, coconut oil and butter fat) and weight change; there were no significant difference between groups male or female.These results agreed with findings obtained by **Alaamet al.,(2012**) who studied compare palm oil, palm olein, palm steatin and corn oil and **Yamasaki et al., (2001)** who found that rats weight gain no significant difference between groups fed different oils (olive, sesame or peanut) as a source fat in diet.

The phenomenon in table (2)appeared that feed efficiency ratio of female groups fed different type offat had significant differences, while there were no significant differences between all male groups or between male and female groups. Olive oil showed the lowest FER for male and female but butter fat was the highest. These results agreed with**Ebru, et al., (2014)** who found the cocoa butter was higher in total feed composition than sunflower oil or blend from cocoa butter and sunflower oil.

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**Table (3)** Changes in serum lipid profile [mg/dl] of rats during experimental feeding on different fat diets (mean ± SE)

| Groups / parameters | sex | Baseline group | Olive oil group | Coconut oil group | Butter group | **P** value |
|---|---|---|---|---|---|---|
| T. lipid | male | 613.0 ±28.7 | 947.6 ±91 | 1166.4 ±154.8 | 1013.8 ±53.4 | 0.033* |
| | %of Baseline | -- | 155 | 190 | 165 | |
| | female | 638.3 ±29.2 | 723.0 ±68.5 | 1008.8 ±99.6 | 858.5 ±49.7 | 0.020* |
| | %of Baseline | -- | 113 | 158 | 134 | |
| **P** value | -- | 0.285 | 0.045* | 0.210 | 0.035* | -- |
| Triglyceride | male | 91.3 ±7.3 | 78.3 ±7.4 | 121.2 ±16.3 | 112.8 ±12.5 | 0.090 |
| | %of Baseline | -- | 86 | 133 | 124 | |
| | female | 83.3 ±2.3 | 71.5 ±8.6 | 122.3 ±8.3 | 103.8 ±12.2 | 0.010* |
| | %of Baseline | -- | 86 | 147 | 125 | |
| **P** value | -- | 0.177 | 0.283 | 0.478 | 0.311 | -- |
| T. cholesterol | male | 107.3 ±3.8 | 103.6 ±1.5 | 164.6 ±10.8 | 150.2 ±14.3 | 0.001* |
| | %of Baseline | -- | 97 | 153 | 140 | |
| | female | 102.7 ±6.6 | 123.3 ±20.2 | 206.8 ±5.3 | 168.8 ±5.9 | 0.0003* |
| | %of Baseline | -- | 120 | 201 | 164 | |
| **P** value | -- | 0.286 | 0.202 | 0.006* | 0.143 | --- |
| HDL | male | 36.2 ±4.7 | 38.9 ±7.6 | 56.2 ±8.3 | 54.6 ±7.0 | 0.199 |
| | %of | -- | 107 | 155 | 151 | |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | Baseline | | | | | |
| | female | 41.6± 0.9 | 35.7± 4.3 | 55.2± 3.9 | 50.8± 7.4 | 0.089 |
| | %of Baseline | -- | 86 | 133 | 122 | |
| **P** value | -- | 0.158 | 0.363 | 0.458 | 0.359 | -- |
| LDL | male | 55.1 ±8.3 | 70.5 ±12.9 | 85.8 ±14.2 | 96.4 ±20.0 | 0.369 |
| | %of Baseline | -- | 128 | 156 | 175 | |
| | female | 44.5 ±6.1 | 72.8 ±18.7 | 104.8 ±7.0 | 96.3 ±8.1 | 0.010* |
| | %of Baseline | --- | 164 | 236 | 216 | |
| **P** value | -- | 0.180 | 0.461 | 0.058 | 0.497 | -- |

*Significant is P< 0.05

Results in table (3) showed that rats (male and female) groups that were fed on coconut oil had the highest percent of serum total lipid. There were significant differences in serum total lipid between groups fed on olive, coconut oil and butter fat compare with baseline group. In addition there were no significant differences in between two six of rat that were fed coconut oil diet, while result showed a significant differences in between male and female rats that were fed butter fat and olive oil diets.

Data in table (3) observed that serum triglyceride level in both male and female rats that were fed on coconut oil diet were highly percentage followed by butter fat diet then olive oil diet. Data also illustrated that all female rats that were fed different fat diet were had a significant differences in serum triglyceride comparing to results ofbaseline group. In contrast, all male rats that received on olive oil butter fat and coconut oil dietshad no significant differences in serum triglyceride. Also, there were no significant differences between male and female rats fed on all fatdiets.

In table (3) male and female rats that were fed on coconut oil diet were higher in serum total cholesterol than groups fed on other source of fat but it differences were significant in related to baselinegroup.

Total cholesterol levels were higher in female rats that were fed on different source of fat than male rats, but there were no significant difference betweenthem fed all source of fat except in coconut oil diet group. HDL and LDL-cholesterol levels were the highest in rats fed on diet with coconut oil andthe lowest in groups fed on diet olive oil, with intermediate levels in rats fed on diet butter fat; all differences among the feeding periods were statistically significant ($P < 0.05$) this trends were apparent in female groups.

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Results in this study confirmed by **Mensink, et al, (2003)** who explained that coconut oil contains a large proportion of lauric acid, a saturated fat that raises total blood cholesterol levels by increasing both the amount of high-density lipoprotein (HDL) cholesterol and low-density lipoprotein (LDL) cholesterol. Although this may create a more favorable total blood cholesterol profile, this does not exclude the possibility that persistent consumption of coconut oil may increase the risk of cardiovascular disease through other mechanisms**(Mensink, et al, 2003),** Because much of the saturated fat of coconut oil is in the form of lauric acid (which raises HDL).

A major proportion of saturated fats of coconut oil are formed of medium chain fatty acids, which do not require a re- esterification process and are oxidized immediately for energy need in the liver **(Guillot, et al., 1993).** Due to this specific characteristic of medium chain fatty acids, it has also been reported that coconut oil cannot be considered hypercholesterolemic**(Reiser, 1973).**

Stearic acid in butter fat is higherlevel than coconut oil that is less absorbed than other fatty acids. Thus, the bioavailability of butter is low **(Weisburger, 2001).** Group rats fed on butter diet showedtheir total cholesterol and triglyceride level lower than group rats fed on coconut oil. In study conducted on rats, cocoa butter diet has been shown to lower cholesterol and triglyceride levels **(Kiitchevsky, et al., 1988).**The saturated fatty acids, except perhaps stearic acid **(Packard et al., 2000),**increase circulating VLDLs, LDLs, cholesterol, and triglycerides (TGs).In addition, saturated fatty acids including stearic acid may predispose platelets to aggregation and facilitate thrombosis **(Kushwaha, &Hazzard, 1977).**

Olive oil has decreases the plasmatic levels of LDL-cholesterol and increases those of HDLcholesterol, hence diminishing the risk of suffering from heart complaints. In this context, it has been suggested that increased consumption of monounsaturated fatty acids in place of polyunsaturated fatty acids will render circulating lipoproteins less sensitive to peroxidation and thereby diminish the development of atherosclerosis **(La Lastra, et al., 2001).**

**Table (4)** Lipid profile in liver tissue of rat that fed on diets with different source of fat (mean ± SE)

| Groups / parameters | Sex | Baseline group | Olive oil group | Coconut oil group | Butter group | **P** value |
|---|---|---|---|---|---|---|
| MDA µmol/g liver tissue | Male | 55.3 ±1.1 | 59.8 ±8.2 | 65.5 ±12.3 | 52.3 ±5.2 | 0.7228 |
| | %of Baseline | -- | 108 | 118 | 95 | |
| | Female | 55.6 ±4.5 | 61.2 ±5.8 | 59.8 ±16.6 | 50.8 ±1.4 | 0.8607 |
| | %of Baseline | - | 110 | 108 | 91 | |

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|---|---|---|---|---|---|---|
| **P** valu e | | 0.474 | 0.458 | 0.196 | 0.391 | -- |
| T. lipid mg/ g liver tissue | Male | 2328.8 ±237.5 | 2966.6 ±402. 4 | 3110.2 ±436.6 | 1901.3 ±342.7 | 0.142 |
| | %of Baseline | -- | 127 | 134 | 82 | |
| | Female | 3239.5 ±676.5 | 1786.5 ±235.8 | 2077.9 ±202.6 | 2819.0 ±510.7 | 0.167 |
| | %of Baseline | -- | 55 | 64 | 87 | |
| **P** valu e | | 0.136 | 0.032* | 0.049* | 0.105 | -- |
| Triglyceride mg/ g liver tissue | Male | 476.7 ±190.2 | 369.4 ±132.0 | 402.4 ±127.1 | 417.1 ±91.9 | 0.956 |
| | %of Baseline | -- | 77 | 84 | 87 | |
| | Female | 358.2 ±67.7 | 243.5 ±32.0 | 345.1 ±43.1 | 491.9 ± 49.9 | 0.177 |
| | %of Baseline | -- | 68 | 96 | 137 | |
| **P** value | | 0.295 | 0.203 | 0.346 | 0.362 | --- |

Significant is P< 0.05

In table (4) found that malonaldehyied (MDA)value that indicated to oxidation in tissue lipid had no significant differences between all groups of rats that were fed on different source of fat or between male and female in each group. Although group fed on coconut oil in both six were the highest percent in MDA while group fed butter had lower in MDA level than two oil and baseline groups.

In the same table clarified that total lipid in tissue for all groups of rats that were fed on different source of fat had no significant differences compare baseline group, while there were significant differences between female and male groups fed olive and coconut oil. Male groups fed coconut oil and olive oil had increased percent in total lipid compare female groups, while female group fed butter had the highest percent in total lipid.

In addition tissue triglyceride value showed that there were no significant differences between all groups fed on different source fat or compare male and female groups. Male and female groups fed on butter fat were the highest percent followed coconut oil then olive oil groups.

This finding was accordance with **Ding et al. (2003)** who observed that the variations from the fatty acid composition of diet in adipose tissue can also arise due to preferential exclusion or incorporation of a particular type of fatty acid into complex lipids. The liver participates in uptake, oxidation and metabolic

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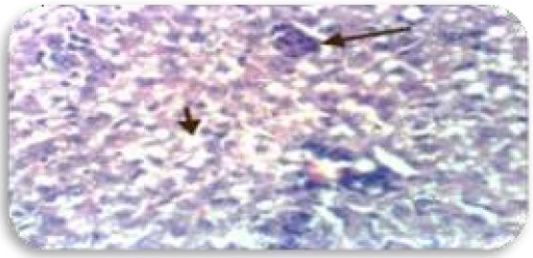
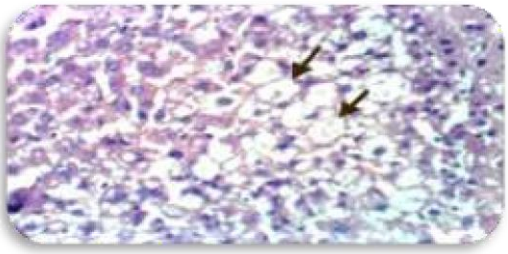
conversion of free fatty acids, synthesis of cholesterol, phospholipids and triglycerides **(Akhtarand Ali, 1984).** Lipid structure, composition and configuration in addition to excessive fat and cholesterol consumption affect the lipid profile in plasma **(Kritchevsky, 1995),** as well as fat tissue deposition **(Yaqoob, et al., 1995)**

<table>
<tr>
<td>  <br>Photo (1): Liver of group (Baseline) (I) showing fatty change of hepatocytes and small focal hepatic necrosis associated with inflammatory cells infiltration (H & E X 400).</td>
<td>  <br>Photo (2): Liver of group (Baseline) (II) showing steatosis of hepatocytes(H & E X 400).</td>
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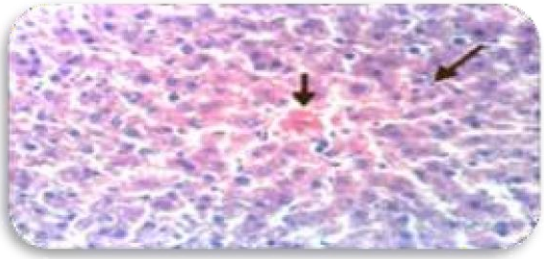
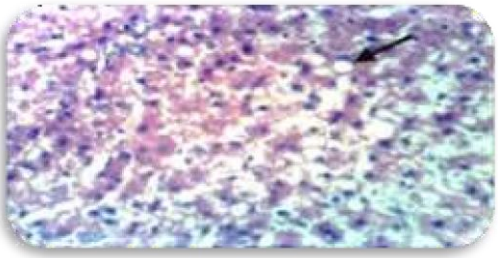
<tr>
<td>  <br>Photo (3): Liver of group (olive oil) (1) showing congestion of central vein and slight activation of Kupffer cells (H & E X 400).</td>
<td>  <br>Photo (4): Liver of group (olive oil) (1) showing fatty change of hepatocytes(H & E X 400).</td>
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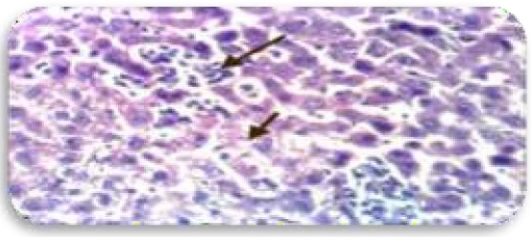
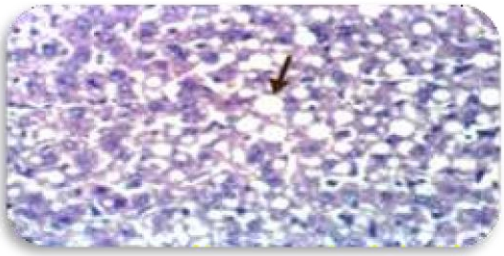
<td>  </td>
<td>  </td>
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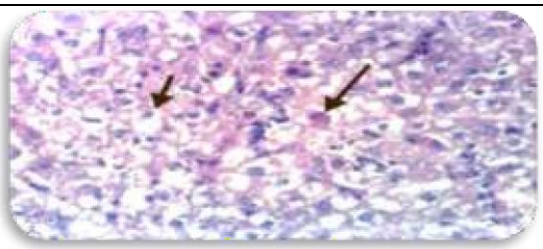
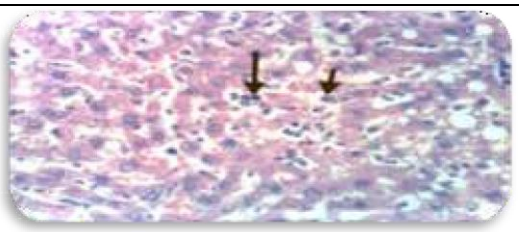
|---|---|
| **Photo (5):** Liver of rat from group (coconut oil) (1) showing fatty change of hepatocytes and sinusoidal leukocytosis (H & E X 400). | **Photo (6):** Liver of rat from group (coconut oil) (11) showing steatosis of hepatocytes(H & E X 400). |
|  **Photo (7):** Liver of rat from group (butter fat) showing steatosis of hepatocytes and apoptosis (H & E X 400). |  **Photo (8):** Liver of rat from group (butter fat) showing fatty change of hepatocytes, apoptosis of hepatocytes and sinusoidal leukocytosis (H & E X 400). |

**Al-Rawi and Ali (2010),**feeding on 10% of diet olive oil rat liver of group revealing loss of the normal radiating pattern with cells slowly turning into large "foam cells" so-described because of their changed appearance resulting from the numerous internal cytoplasmic vesicles .The cells contained high lipid content and pyknotic nuclei with loss of their polyhedral shape. Foam cells eventually die, and further propagate the inflammatory process.

**Alaam et al., (2012)**showed feeding on palm olein dietary oil as a source saturated fatty acid caused a dilatation and congestion of the central vein also, a dilatation and congestion of the portal vein with distention bile duct was noticed, while a normal structure of the surrounding hepatocytes were observed in rats liver. Concerning the liver of rats group fed on palm oil, showed a few fatty changes in hepatocytes with inflammatory cells infiltration in between the hepatocytes; in addition of fibrosis with inflammatory cells infiltration in the portal area.

**Alwan, (2009)** reported histological examination of liver tissues section of hypercholesterolemic rabbits revealed hyperatrophic hepatocytes, hardly apparent sinusoids with fatty infiltration these may be due to increase the level of cholesterol and other lipids in the blood and therefore the liver uptake these increase in levels to oxidation and metabolism to decrease these levels and increase excreted with urine and feces.

**Conclusion**

Dietary fatty acids influence several aspects of cholesterol metabolism including cholesterol absorption, bile acid synthesis, biliary cholesterol secretion, hepatic VLDL synthesis, and LDL clearance from the circulation. With respect to plasma cholesterol concentration, SFA are generally considered to be

hypercholesterolemic compared with dietary carbohydrate, whereas monounsaturated fatty acids are thought to be neutral or mildly hypocholesterolemic, and PUFA are hypocholesterolemic. Categorizing dietary fatty acids according to degree of saturation has been useful in developing dietary recommendations, although individual fatty acids within the same saturation category can have very different and specific effects on cholesterol metabolism.

The findings suggest that, in certain circumstances, coconut oil might be a useful alternative to butter and hydrogenated vegetable fats. However, it should be noted that in individuals and populations with a tendency to obesity, all fat sources should be restricted and that depending upon the requirements of individuals, fats high in stearic acid or cis-monounsaturated fatty acids may be preferable to coconut oil.

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