Evaluation of the Activity of Glucose-6-Phosphate Dehydrogenase and Some Fatty Acids, Lipid Profile Level in Patients with Glucose-6-Phosphate-Dehydrogenase Deficiency

Wdyan Jassim Ali Latif[1], Asma Hashim Shakir[2]
[1,2]University of Tikrit, College Education for girls, Department Chemistry/Iraq
Email: Wdyan.Ali200@st.tu.edu.iq

Abstract
The study included evaluating the activity of the enzyme glucose-6-phosphate dehydrogenase and some fatty acids In the sera of patients with glucose-6-phosphate dehydrogenase deficiency, the study was a group of 118 blood samples, 40 samples from healthy people (control), distributed between 34 and 24 females. Samples were collected from outpatient clinics in Baghdad city and Dhuluiya district, logic between 2020/ 11/20 to 3/15/2021.The current study included evaluating glucose-6-phosphate dehydrogenase enzyme activity, and (cholesterol, Triglycerides, high-density lipoprotein, low-density lipoprotein the study included a study to estimate the proportion of fatty acids represented by (oleic acid, linoleic, linolenic, palmitic, stearic) in the three main parts, including phospholipids, triglycerides and cholesterol ester in the patients. The current study It showed significant decrease in G-6-P-D at the probability level of P≤0.05 in the blood serum of patients compared to the healthy group. also the result showed significant decrease in (T.C, T.G, HDL-C) at the probability level of P≤0.05 in the blood serum of patients compared to the healthy group. but the results showed an increase in the LDL-C in the blood serum of patients compared to the healthy group. The result showed the percentage of fatty acids in the phospholipid fraction did not show any significant differences in the blood serum of patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy controls. As for the proportion of fatty acids in the triglyceride fraction, it showed a significant increase in the blood serum of patients with glucose-6-phosphate dehydrogenase deficiency, while the proportion of fatty acids in the cholesterol ester fraction showed no significant differences between patients and healthy subjects.
Keywords: G-6-P-D, Fatty acid, lipid profile.

1. Introduction

Glucose-6-posphate dehydrogenase –G-6-P-D It is one of the redox enzymes Oxidoreductas EC 1.1.1. 49 It can be described for the first time by Warburg and Christion in 1931 (1), and it is a cytoplasmic enzyme that spreads in all cells of the body, especially in red blood cells (2), and it is one of the most important metabolic enzymes as it is the first and main key to the hexose monophosphate shunt HMPS stimulates the oxidation of glucose-6-phosphate and converts it to 6-phospho glucono-δ-lacton. In this way, it reduces the oxidative energy transporter Nicotine amide adenine di-nucleotide phosphate (NADP+) and converts it to the active form NADPH (3). Maintaining the vitality of the erythrocyte membrane (4).

It is the main enzyme in the pathway of pentaglycerides, so its deficiency causes the depletion of NADPH in red blood cells (5), so the deficiency of this enzyme may cause death, in addition to that its deficiency can cause death as a result of acute kidney failure as a result of obstruction of the renal tubules mediated by hemoglobin. Released from the lysis of red blood cells (6).

The deficiency of this enzyme also leads to a case of hemolytic anemia resulting from the breakage of red blood cells, and this breakage rate rises in individuals with enzyme deficiency when exposed to any oxidizing substance, whether it is external, such as bean sprouts, as a result of containing two compounds, Convieine and Vieine, or the abuse of some drugs. Oxidants, or endogenous oxidizing substances formed inside the human body as a result of metabolic processes or due to some infections, including viral infections such as acute and chronic viral hepatitis (7).

There are many diseases that are associated with G6PD deficiency, including sickle cell anemia (8), Thalassemia (9), Neonatal Jaundice (10), and cataracts (11).

Fatty acids are found in the body freely (non-esterified) and are included in the composition of fats, including phospholipids and sugar fats, and they consist of a saturated or unsaturated hydrocarbon chain with a carboxylic end, and they are found in a high percentage in the plasma, reaching a rate of (90%) and are found in the form of esters Fatty acids such as (triacylglycerol, cholesterol ester, and phospholipids) (12), The most important fatty acids that are included in the composition of all animal and vegetable fats are plastic acid (C16: 0) and stearic acid (C18: 0), and the distinctive components of oils are unsaturated fatty acids, as oleic acid (C18: 1) is one of the most important. It is

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widespread (13), and there are essential fatty acids due to the human inability to form them, including linoleic, linolenic and arachidonic acid, and these acids contain double bonds of two, three and four, respectively, and they are important acids for growth, and plants are the important source of essential fatty acids (12).

2. Material and Methods

Sample Collection: 60 blood samples were collected from patients with glucose-6-phosphate dehydrogenase deficiency for outpatient clinics in Baghdad city and Al-Dhuluiya / Salah Al-Din district for both sexes. Healthy people (control group) were distributed between 34 males and 24 females, where samples were collected, for the period from 20/11/20 to 15/3/2021.

Methods:The study include determination of :

Estimation of G-6-P-D

The enzyme activity in red blood cells was estimated using the diagnostic kit supplied by the French company, as the principle of the examination depends on the speed of release of NADPH by the enzyme and the absorbance of the formed compound is measured at the wavelength of 340 nm [14]. The activity of glucose-6-phosphate dehydrogenase enzyme was calculated according to the following equation [15].

$$\text{IU/g Hb} = \frac{(\Delta Abs/\text{min} \times 5000)}{Hb\ g/dL}$$

Estimation of lipid profile level

The sensory level of total cholesterol was estimated by the method [16], the level of triglycerides by the method [17], the level of high-density lipoprotein according to the method [18] and the level of low-density lipoprotein according to the method [19].

Lipid Extraction

Extracting fats from blood serum

(1) ml of the separated blood serum was withdrawn, and fat was extracted from it as follows:

Add (2) ml of methanol to the blood serum (sample) and shake well. Then the extraction process was carried out by adding (4) ml of chloroform with shaking, then filtering the resulting solution [20]. After that, the resulting solution is concentrated to a volume of (1) ml. Through the application of nitrogen gas (or the use of pressure relief), the fat remains dissolved in (1) ml of methanol, then these samples are passed and separated through thin layer chromatography (TLC) technology.

Fat separation by thin layer chromatography

Characteristics of chromatographic plates

Thin-layer chromatography plate consists of a glass plate or aluminium, plastic, industrial elastomer with dimensions (20 x 20) cm coated with a layer of silica gel with a thickness of 0.25 mm, and it is ready-made from (Germany MERCK) company.

Activate the plates immediately before use, by placing the plate in an electric oven at a temperature of (100-120) annually for a full hour, to be used immediately after cooling [21].

Solvents in the stationary phase

There is more than one mobile phase that can be used to separate several types of fats. The most stable and suitable of these solvents for this study is the use of a mixture of (hexane, ether, formic acid) at a ratio of (2:20:80) (171) (v: v).

Form Applications

Then (30) microliters of the solutions extracted from the blood serum were placed on the chromatograph plate by a micropipette, and it was left to flow upward for one hour inside the vessel of the technique.

3. Statistical Analysis

The SPSS statistical program was used to analyze the result between patients and control using the T. Test and at a probability level P≤0.05.

4. Results and discussion

Measurement of the G-6-P-D, Cholesterol, T.G, HDL-C,LDL-C level in the samples under study

Table (1): - shows the Mean ± S.D of the variables studied in the research

Parameters	Mean ±S. D		P≤
	Control	Patients	
G.6.P.D IU/g	2324 ± 51	397 ± 38	0.0008
Cholesterol mg/dl	170.1 ± 21.6	125.4 ± 17.4	0.0003
Tri glyceride mg/dl	167.3 ± 65.6	125.2 ± 55.4	0.0002
HDL mg/dl	58.02± 4.51	42.33± 7.08	0.0006
LDL mg/dl	105.1± 26.6	110.0± 20.0	0.505
**P<0.05			

Evaluation of G-6-P-D activity in all groups

The study included estimating the activity of glucose-6-phosphate dehydrogenase enzyme in patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy controls. The result showed a significant decrease in the activity of G-6-P-D enzyme in the blood serum of patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy subjects.

When comparing the activity of G-6-P-D enzyme by sex, the results showed that the activity of G-6-P-D enzyme was significantly decreased at the level of probability P≤0.05, as its level reached (367.3 ± 44.1) (2303.2 ± 65.1) IU/gm in male patients Patients with G-6-P-D enzyme deficiency and healthy group, respectively, and the results showed a decrease in the activity of G-6-P-D enzyme in females, as its level reached (442.1 ± 25.2), (2354.0 ± 58.2) IU/gm for both patients and healthy group on the Res pectively, and when comparing the effectiveness of G-6-P-D between the sexes in patients, the results showed no significant differences as well as among

healthy group , as shown in Figure (1).

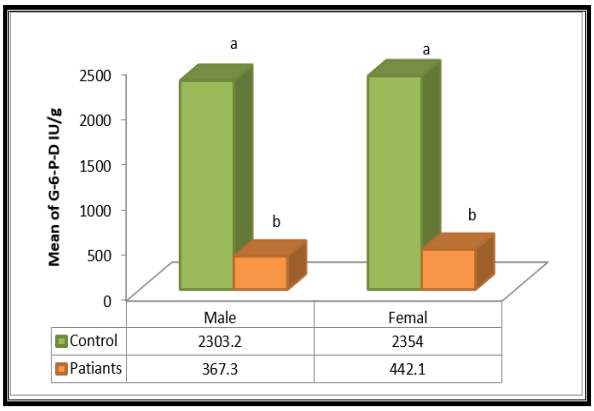


Figure (1): - G-6-P-D enzyme activity in patients with G-6-P-D enzyme deficiency compared to healthy controls by gender

The results agreed with Evan [22] and Avier [23], who indicated in their study that there is a significant decrease in the activity of G.6.P.D enzyme in the group of hemolytic anemia patients compared with the healthy group, as the decrease in the effectiveness of this The enzyme affects all cells of the body, including the red blood cell, as it is more affected by the deficiency of the enzyme. The reason is that the main action of the enzyme G6PD is to protect the reduced glutathione in the red blood cell through the formation of the reduced energy transporter NADPH, and in the absence of glutathione or a decrease in its concentration in the red blood cell. This leads to an increase in oxidative stress on the globule membrane, and this results in a state of hemolysis [24].

There are many factors, such as some antibiotics, anti-malarial drugs, some types of sedatives and stimulants, and eating uncooked beans, which lead to a state of hemolysis associated with G6PD enzymatic deficiency. The activity of the enzyme affects these sites where the enzyme spreads, but to a lesser extent than the rate of infection of the red blood cells [25].

Evaluation of Cholesterol in serum blood in all groups

The study included estimation of lipid levels (cholesterol, triglycerides, high-density lipoprotein, low-density lipoprotein) in patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy controls. The results shown in Table (1) a decrease Significantly and at the probability of P≤0.05 in the levels of lipids (cholesterol, triglycerides, high-density lipoprotein) in the blood serum of patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy controls. also, the results showed that were no significant differences in the level of low-density lipoprotein between patients and healthy group.

A comparison was also made for lipid levels by sex, as the results showed that the cholesterol level was significantly decreased at the probability level of P≤0.05, as its level reached (125.57 ± 22.11) (161.42 ± 28.89) mg/dl among male patients with G-6 –P-D enzyme deficiency and healthy group , respectively, and the results showed a decrease in the level of cholesterol in females, as its level reached (138.75 ± 17.55), (229.87 ± 16.38) mg/dL for both patients and healthy group, respectively, and the results showed no significant differences in the level of cholesterol between The sexes for the group of patients and healthy group, as in Figure (2).

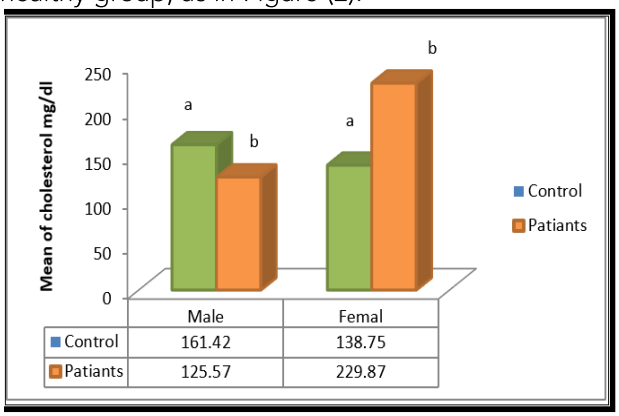


Figure (2): - Cholesterol level among people with G-6-PD deficiency compared to healthy people by gender

On the other hand, when comparing the level of T.G by sex, the results showed that the level of T.G did not show significant differences between patients and healthy group, as its level reached (116.25 ± 19.07) (123.20 ± 15.76) mg/dl in male patients with G-6- P-D deficiency. and healthy group, respectively, but the results showed a decrease in the level of T.G in females, as its level reached (138.75 ± 17.55) and (229.87 ± 16.38) mg/dl for both patients and healthy group, respectively, and as in Figure (3).

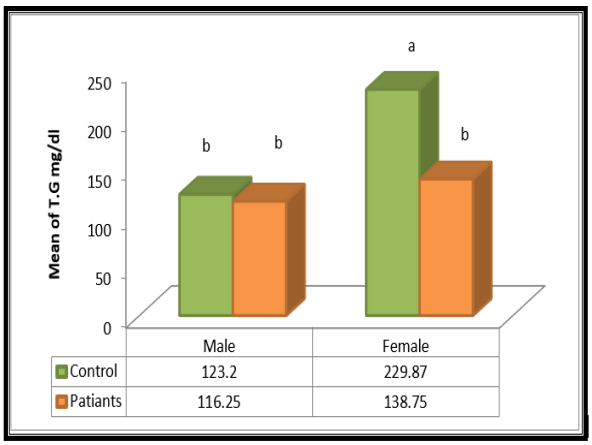


Figure (3): - The level of T.G in people with G-6-P-D deficiency compared to healthy people by gender

Also, a comparison was made for the level of HDL-C by sex, as the results showed that the level of HDL-C decreased significantly and at the level of probability P≤0.05, as its level reached (42.600 ± 7.640) (59.848 ± 3.615) mg / dl among the male patients affected The results showed a decrease in the level of HDL-C in females, as its level reached (41.910 ± 6.270) and (55.512 ± 4.467) mg/dl for both patients and healthy subjects, respectively. The results showed that there were no significant differences between the sexes for patients and healthy group, as shown in Figure (4).

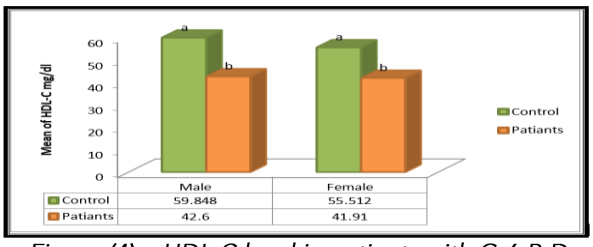


Figure (4): - HDL-C level in patients with G-6-P-D enzyme deficiency compared to healthy controls by gender

On the other hand, a comparison was made to the level of LDL-C by sex, as the results showed that the level of LDL-C was significantly decreased at the level of probability P≤0.05, as its level reached (70.53 ± 14.58) (109.15 ± 15.30) mg / dl in male patients with enzyme deficiency The results showed an increase in the level of LDL-C in females, as its level reached (167.59 ± 12.22) and (99.44 ± 17.73) mg/dl for both patients and healthy subjects, respectively. The results also showed that The level of low-density lipoprotein was increased in the blood of females compared to males, as shown in the figure. (5).

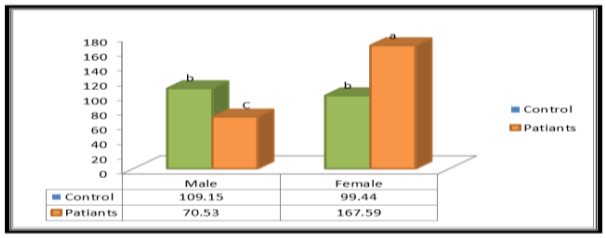


Figure (5): - HDL-C level in patients with G-6-PD enzyme deficiency compared to healthy controls by gender

The results of the current study agree with Ihsan (26) and Bulent Atac (27), who showed in their study a decrease in cholesterol level in patients with hemolytic anemia compared with the control group. Hemolysis may cause thalassemia, sickle cell anemia and hemolytic anemia, which leads to excess iron, and excess iron affects cholesterol levels, (28) as it was shown that iron accumulation may cause an imbalance in target organs such as liver, heart and pancreas, and this affects cholesterol synthesis, especially in the liver. A patient with G6PD deficiency has lower levels of total cholesterol and LDL than healthy subjects (29). G6PD deficiency hemolytic anemia may cause decreased synthesis of cholesterol and LDL-linked mRNA (30).

On the other hand, the literature did not indicate a relationship between triglycerides, high-density lipoprotein, low-density lipoprotein and glucose-6-phosphate dehydrogenase deficiency. Thalassemia patients compared with the control group (31).

Analysis and estimation of fatty acids in the blood serum

Thin-layer chromatography (TLC) technique was used to measure the percentage of fatty acids of the three parts in the blood serum (cholesterol ester, triglyceride, phospholipids) resulting from the separation of serum lipids using a solvent system consisting of (hexane / ether / formic acid) and then re-esterification Fatty acids for each of the three parts and using standard models, the process of diagnosing and analyzing the percentage of each part of the fatty acids used and represented by (oleic acid, linoleic, linolenic, palmitic, stearic).

Show figur (6,7,8,9,10) represent the figures resulting from the analysis and estimation of the fatty acids in the blood serum for the three parts (cholesterol ester, triglycerides and phospholipids) using the GC technique for standard models. The figures (11,12,13,14,15,16,17,18,19) represent the samples, and the table (2) shows the percentage and retention time for the appearance of standard fatty acids.

Table (2): - Percentage and retention time for the appearance of standard fatty acids

No	Palmatic %	Oleic %	Linolic %	Stearic %	Lenolinic %
1	8.05	16.25	11.48	2.00	0.36
2	11.49	24.58	16.55	3.56	0.58
3	9.25	20.14	14.25	2.14	0.40
4	8.11	16.55	11.40	2.01	0.34
5	12.50	25.19	16.05	3.11	0.51
6	9.44	19.58	14.00	2.06	0.41
7	8.19	16.35	11.52	2.01	0.35
8	11.49	24.16	17.11	3.69	0.54
9	9.23	19.88	14.36	2.55	0.46
10	8.13	16.49	11.36	2.03	0.36
11	12.08	24.88	16.49	3.98	0.59
12	9.25	20.16	14.08	2.14	0.45
13	8.05	16.08	11.25	2.05	0.31
14	11.68	25.09	16.98	3.15	0.58
15	9.66	20.44	14.25	2.35	0.42
16	8.06	16.33	11.89	2.10	0.32
17	11.59	25.23	16.35	3.10	0.54
18	9.47	20.10	14.33	2.36	0.41
19	8.01	16.98	11.56	2.01	0.36
20	11.16	24.19	16.08	3.08	0.50
21	9.85	19.85	14.99	2.89	0.46
22	8.06	16.22	11.25	2.06	0.31
23	12.30	24.99	17.04	3.25	0.52
24	9.05	19.66	14.20	2.45	0.41
25	8.11	16.08	11.06	2.00	0.32
26	11.59	24.65	17.14	3.55	0.56
27	9.15	19.26	14.79	2.51	0.42
28	8.09	16.46	11.15	2.05	0.36
29	11.26	25.18	17.19	3.49	0.55
30	9.60	19.36	14.36	2.19	0.44

The percentage of fatty acids in the phospholipids in the blood serum

The results showed, according to Table (3), that there were no significant differences in the percentage of fatty acids in the blood serum of patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy controls.

Table (3): - shows the percentage of fatty acids in the phospholipid fraction in the blood serum of the samples under study\			
Fatty acid	Control group	Patiants group	P
Olic acid	8.520±0.200	16.379 ± 0.265	0.00002
Linolic acid	10.080 ±0.020	11.392 ±0.238	0.0007
Linolinic acid	2.4800 ± 0.0100	0.3390 ± 0.0218	0.0008
Palmatic acid	8.440 ±0.4400	8.086 ±0.0513	0.299
Stearic acid	2.1400 ±0.0200	2.0320 ±0.0326	0.001
Total number	6.33 ± 0.471	7.65 ± 1.620	0.713

Percentage of fatty acids in the triglyceride fraction in the blood serum

The results showed, according to Table (4), a significant increase in the level of fatty acids in the blood serum of patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy people.

Table (4): - shows the percentage of fatty acids in the phospholipid fraction in the blood serum of the samples under study			
Fatty acid	Control group	Patiants group	P
Olic acid	10.400 ± 0.100	24.814 ± 0.403	0.00008
Linolic acid	9.200 ± 0.200	16.698 ± 0.446	0.0009
Linolinic acid	2.5400 ± 0.0200	0.5470 ± 0.0309	0.008
Palmatic acid	8.000 ± 0.500	11.714 ± 0.440	0.01
Stearic acid	2.200 ± 0.100	3.396 ± 0.305	0.0005
Total number	6.47 ± 1.84	11.43 ± 2.87	0.043

Percentage of fatty acids in the cholesterol ester fraction

The results showed, according to Table (5), that there were no significant differences in the percentage of fatty acids in the blood serum of patients with glucose-6-phosphate dehydrogenase deficiency compared to healthy control.

Table (5): - shows the percentage of fatty acids in the cholesterol ester fraction in the blood serum of the samples under study			
Fatty acid	Control group	Patiants group	P
Olic acid	10.000 ± 0.500	19.843± 0.378	0.001
Linolic acid	10.040 ± 0.040	14.361± 0.306	0.009
Linolince acid	2.300 ± 0.1000	0.428 ± 0.0225	0.001
Palmatic acid	8.400± 0.200	9.395± 0.253	0.02
Stearic acid	2.160 ± 0.020	2.364 ± 0.250	0.031
Total number	6.65 ± 1.11	9.33 ± 2.16	0.541

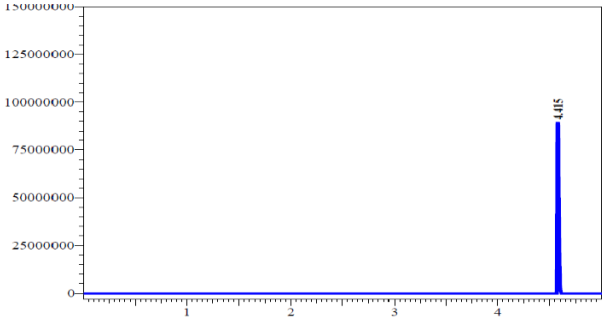


Figure 6: - Standard curve of linolenic acid

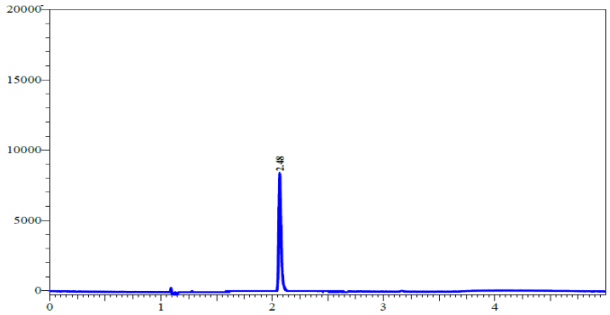
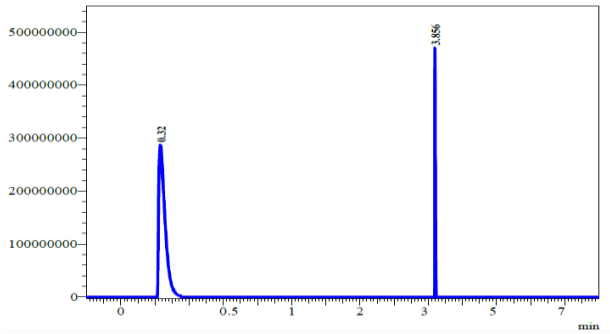


Figure (7): - Standard curve of linoleic acid



Figure(8): - Standard curve of oleic acid

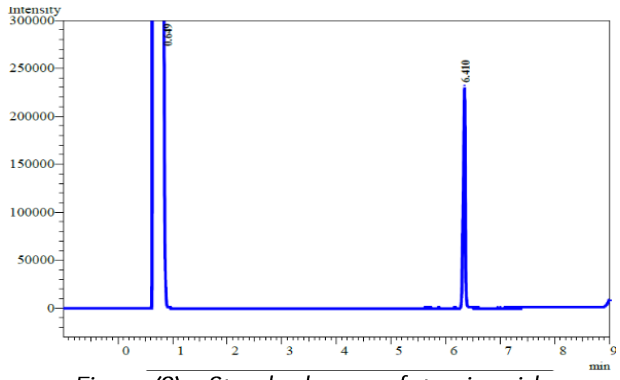


Figure (9): - Standard curve of stearic acid

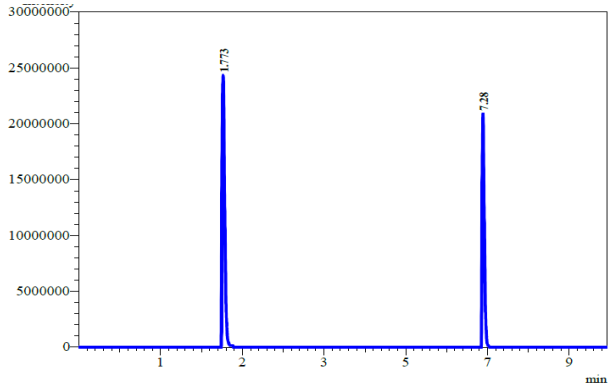


Figure (10): - Standard curve of palmitic acid

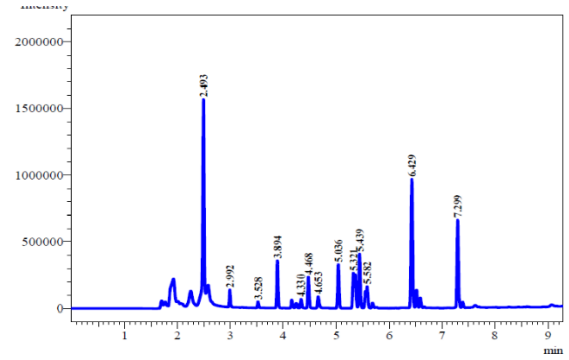


Figure (11): - The first sample of phospholipids

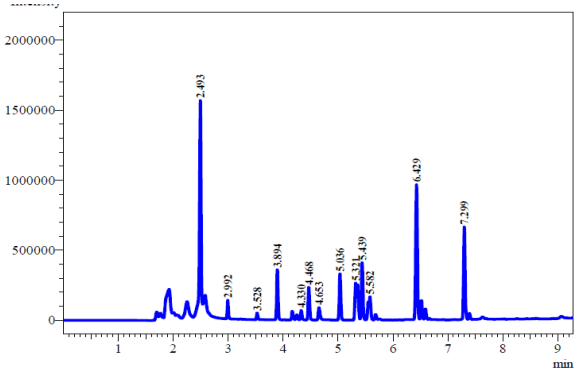


Figure (12): - The first sample of triglycerides

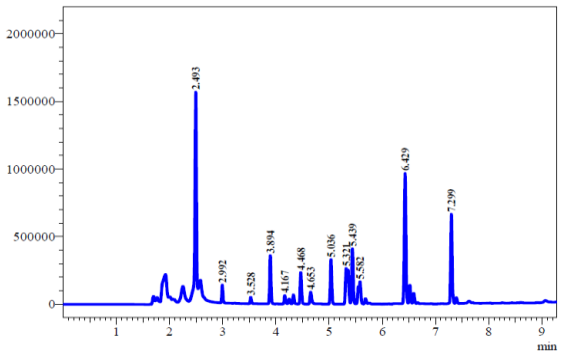


Figure (13): - The first sample of cholesterol ester

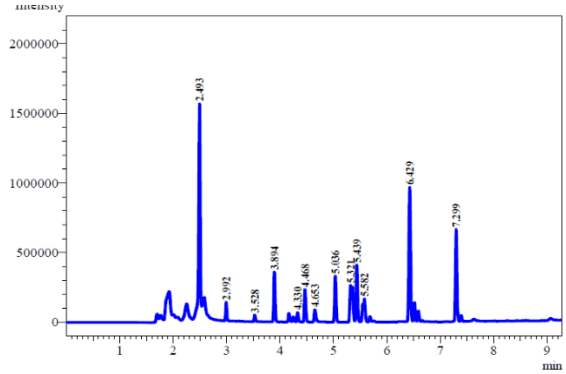


Figure (14): - The second sample of phospholipids

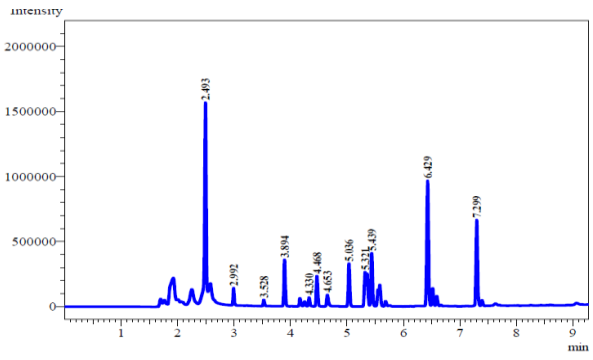


Figure (15): - The second sample of triglycerides

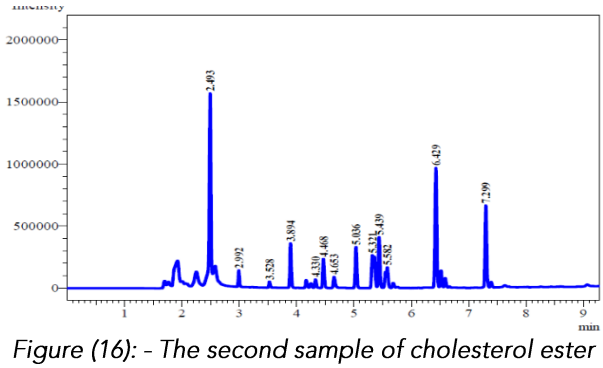


Figure (16): - The second sample of cholesterol ester

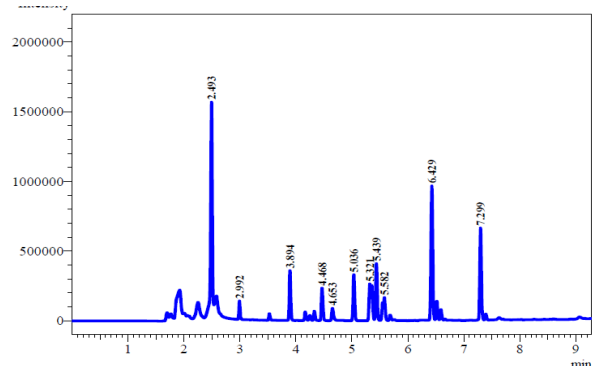


Figure (17): - The third sample of phospholipids

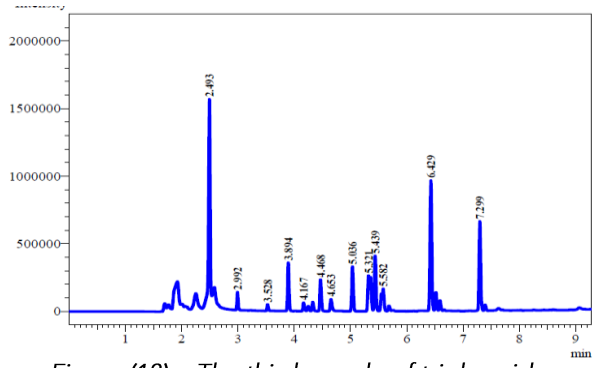


Figure (18): - The third sample of triglycerides

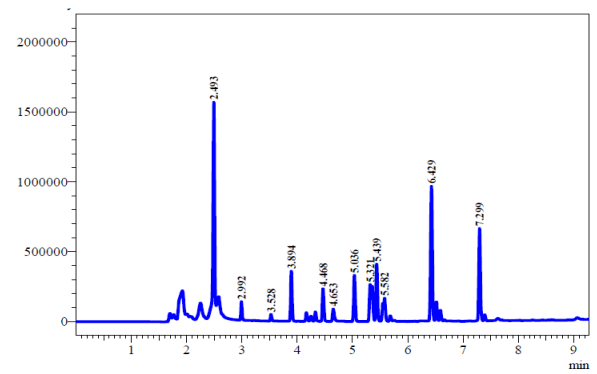


Figure (19): - The third sample of cholesterol ester

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