Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Evaluation Of The Effect Of Rybelsus On The Histological Structure Of The Liver In The White Mouse

Shahad Ali [1], Thekra Atta Ibrahim [2]

[1,2] Biological Department – College of Education for Pure Sciences – University of Diyala, Diyala, Iraq.
Correspond author. Email: pbio.shahadalinajim@uodiyala.edu.iq

The present study was conducted to determine the effect of some anti-obesity drugs on the histological structure of the liver and kidney in Swiss mice (Mus musculus) for 30 days. Twenty mice were used and each group was placed in a separate cage and divided into two groups, each group containing 10 mice. The first group was the control group where its animals were injected by distilled water, while the second group was the first experiment group where its mice were injected by the Rybelsus drug at a concentration of 0.6 mg/day. On the last day, the treated animals were sacrificed, their kidneys and livers were extracted very carefully, and tissue sections were prepared by embedding in paraffin wax. The sections were then stained using two types of dyes which were hematoxylin and eosin (H&E). Finally, the histological sections were tested using a light microscope equipped with a digital camera, and the required information was recorded. Several histopathological changes were recorded in the liver tissue of animals treated with Rybelsus drug, where cellular changes appeared represented by hepatic cell enlargement, and hilar degeneration was seen in some hepatic cells. Nuclei enlargement, edema, thickening and decomposition of some hepatic cell nuclei were also seen. Hepatic cell scattering was also observed, as well as clear congestion in the central vein and portal vein, in addition to an increase in the size and number of Kupffer cells as well as dilatation of the sinusoids. Granulation and focal necrosis were also observed in the liver tissue and infiltration of inflammatory cells in the liver parenchyma as well as in the portal yard, and hyperproliferation of bile ducts was observed. The results of this study also showed that the weights of animals treated by the previously mentioned concentrations of Rybelsus drug were affected, as the weight rates of all experimental groups decreased and the average weights of animals dosed for 30 days were (25.5 - 28) g.

Introduction: Human health is exposed to dangerous conditions and sometimes death in the long or short term (Abbas and Abbas, 2013a), as a result of pollutants and toxic substances that move from environmental elements such as water (Ali et. al., 2020a), air and soil (Abbas et. al., 2021) to reach humans through the food chain (Maddodi et. al., 2020). Exposure, handling or accumulation of various chemicals such as heavy metals (Abbas and Abbas, 2013b), dyes (Alalwan et. al., 2021), inorganic toxins (Alalwan et. al., 2020), organic acids (Abbas and Abbas, 2014), carcinogenic substances from different resources (Alhamd et. al., 2024a), radioactive elements (Alalwan et. al., 2018), hardness (Ibrahim et. al., 2021), oil waste (Ali et. al., 2021), medicines (Ibrahim et. al., 2020a), drugs (Ibrahim et. al., 2020b), chemicals (Abbas et. al., 2019a), tree leaves (Hameed and Abbas, 2024), pesticides (Abd ali et. al., 2018), phenols (Abbas et. al., 2019b), industrial (Ghulam et. al., 2020) and agricultural waste (Abbas and Abbas, 2013c) and others (Ali et. al., 2024), and even the necessary substances that the human body needs such as elements (Al-Hermizy et. al., 2022) or vitamins (Ali et. al., 2020b) can have a toxic effect on the body after a period of time that varies according to the type, age, gender and weight of the organism. One of these substances that have not been highlighted and their effects studied sufficiently are medications (Khaleel et. al., 2022). The use of medications that are not recommended may lead to dangerous conditions and sometimes death as a result of their various effects on the activities and activities of the body's organs (Hashem et. al., 2021). Humans use medications to treat the effects of disease, but some of these medications may cause side effects and unwanted effects that affect public health or have toxic effects (Hasan et. al., 2021). Although there are many methods that provide solutions and treatments for these pollutants, either by removing them (Abbas et. al., 2020) or trying to benefit from them in different ways in eco-friendly approach (Alhamd et. al., 2024b), by converting them into useful materials, such as additives (Abdulkareem et. al., 2023), alcohol (Hamdi et. al., 2024), chemicals (Abbas et. al., 2022a), pesticides (Abd Al-Latif et. al., 2023), fertilizers (Abbas, 2015), catalyst materials (Abbas and Alalwan, 2019), nanao-particles (Alminshid et. al., 2021), fillers (Abbas et. al., 2022b), or other methods to dispose of them (Rajaa et. al., 2023), the levels of pollution that humans are exposed to from these various materials, which affect their health in one way or another (Abdullah et. al., 2023), are still high and without an accurate and updated definition of their effects (Alwan et. al., 2021). People are increasingly interested in fitness and physical health, which has led them to look for any food products, drugs or medicines that contribute to weight loss and maintain general health at the same time (Rippe, 2018). Among these products, special emphasis is placed on slimming products, which lead to losing excess weight and in the same time containing many chemicals (Ali and Abbas, 2020). Slimming products are defined as a group of products or nutritional elements that are intended to help people lose weight, maintain a moderate weight, or achieve a healthy or ideal weight (Ryan, 2021). Slimming products are commonly used as part of healthy weight loss strategies and vary in their composition and methods of use, and usually include low-calorie foods, nutritional supplements, medications, and natural products that are claimed to have slimming effects (Al-Ali et. al., 2023). The increasing use and popularity of slimming products is growing due to their availability and improved awareness of the importance of weight management and maintaining overall health (Lean et. al., 2018). Many slimming products are used to help control weight and reduce obesity, a condition that can lead to various health risks such as high blood pressure and diabetes (Abbas and Nussrat, 2020). The use of curves is a suitable alternative for people who prefer to avoid surgical procedures, which contributes to reducing the need for unwanted surgical interventions (Cohen & Gadde, 2019). In addition, some curves offer oral medications, providing another option for people who prefer to receive oral medication treatments instead of surgical procedures (Curthoys & Moe, 2014). But using slimming pills (like any chemicals) is not an absolute benefit, but rather a double-edged sword (Abbas and Ibrahim, 2020). Despite the health benefits of slimming pills, they must be used with caution, in specific doses and times, and under the supervision of a doctor or nutritionist to avoid potential health risks (Williams et. al., 2019). Using diets without the supervision of a doctor or nutritionist may cause several health problems, including side effects such as high blood pressure, headache, irritability, insomnia, and others. Or some diets may be poor in essential nutrients such as proteins, vitamins, and minerals, which can lead to malnutrition. In addition to the above, the unbalanced use of diets may be associated with negative effects on mental health such as anxiety, depression, and nervous tension. While some diets may cause digestive disorders such as constipation, diarrhea, or intestinal irritation. Last but not least, their effects on cardiovascular functions, which increases the risk of heart disease and stroke (Brewis & Trainer, 2024). One of the most widely used types of slimming pills is the drug Rybelsus. This type of slimming pill is an interesting option for people seeking to lose weight, due to its low calories and its effectiveness in stimulating the fat burning process without affecting a healthy weight (Iijima et. al., 2023). Rybelsus is an oral medication used to treat type 2 diabetes. Rybelsus contains the active ingredient semaglutide, which stimulates the release of insulin from the beta cells (β-cells) in the pancreas. Semaglutide is thought to work by binding to glucagon receptors in the pancreas, which increases insulin secretion and decreases glucagon secretion. Insulin lowers blood sugar levels by promoting the uptake of glucose from the blood into cells for use as energy, while glucagon increases the release of glucose from the liver into the blood (Stafeev et. al., 2024). Rybelsus is usually available as tablets that are specially designed to dissolve under the tongue rather than swallowed, to allow the medication to be absorbed quickly and effectively through the blood vessels under the tongue (Tan et. al., 2024). Rybelsus is given by placing a sublingual tablet and dissolving it under the tongue about 30 minutes before breakfast, as it dissolves and is quickly absorbed into the blood, allowing it to start working faster through the bloodstream (Karásek, 2022). Rybelsus can be used independently as a single treatment for type 2 diabetes. It can be used with other medications used to treat diabetes such as metformin or insulin, according to the recommendations of the treating physician, and also according to the patient's condition and individual health needs (Andersen et. al., 2021). This type of slimming product, especially Rybelsus, has recently become increasingly popular, as it is a nutritious and (to a certain extent) safe option for users. This drug is seen as an ideal alternative for people seeking to maintain a healthy weight and improve their overall quality of life. However, the use of this drug is not 100% safe, as side effects have been reported as a result of using this drug (Rubino et. al., 2022). The most common side effects of Rybelsus in adults included nausea, diarrhea, constipation, vomiting, injection site reaction, low blood sugar (hypoglycemia), headache, fatigue, dizziness, stomach pain, and change in lipase enzyme levels in the blood. Additional common side effects in children were fever and gastroenteritis (Shaman et. al., 2022). The liver plays an important role in the body's efficient metabolic processes. It is responsible for the intermediate metabolism of proteins, carbohydrates and lipid compounds. The liver is a very effective organ in detoxifying and removing toxic compounds and other harmful substances (Abd Ali et. al., 2024). Given the great importance of the liver in the continuity and quality of life due to the multiple locations and functions it performs, and the lack of most previous research on the histological effects caused by depressants on it, this study aimed to clarify the negative effects of the drug Rybelsus on the histological structure of the liver.

Materials and Methods

Drug Doses & Method of Administration: Rybelsus is used in the form of tablets containing 14 mg of the active substance Semaglutide, which is obtained from the pharmacy and manufactured by the Danish company Novo Nordisk. The specific dose of Rybelsus drug was 0.6 mg, which is the oral dose and the intraperitoneal dose in mice. The amount of drug injected into the mice used in this study was calculated based on the equation 1 (Abd ali et. al., 2018):

$$\frac{\mathrm{x}}{\mathrm{D}} = \frac{\mathrm{W_{mouse}}}{1000} \qquad \dots (1)$$

Where: x: is the weight to be injected into the mice in the experiment, measured in mg, D: is the specified dose of Rybelsus, which is 0.6 mg, $\mathrm{W_{mouse}}$: is the weight of the mice used in the experiments, which ranged between 28-43 g.

Preparation of animals: 30 Swiss white mice of both sexes, male and female, aged 3-4 months, weighing 19-43 grams, were prepared and raised in the animal house, by placing them in plastic cages covered with metal mesh covers, measuring 30 × 50 × 20 cm. The cage floors were covered with sawdust, and they were cared for and provided with water and feed. The animal cages were cleaned every day and sterilized with disinfectants. The animals were then placed in suitable laboratory conditions in terms of ventilation and lighting at a temperature of 23-26 C.

Dissection of Animals and Preparation of Histological sections: The mice were dosed for thirty days with Rybelsus, after which their Livers were removed for tissue section analysis and the animals were dissected. The tissue sections were prepared using the method described by (Suvarna et. al., 2019) after the tissues were fixed for 24 hours in a 10% formalin solution. The slides were colored using hematoxylin-eosin dye in order to evaluate how Rybelsus impacted the histological makeup of the liver.

Results

Histological Description of Liver in Control Group: The results of microscopic examination of the liver tissue sections of animals in the control group showed that the liver tissue consists of several lobules, each containing a central vein in the middle of the lobule, and the hepatocytes extend around it in a regular radial manner in the form of hepatic cords. The hepatocytes are polygonal in shape, containing one circular nucleus and sometimes two binucleated nuclei. Light-colored areas were observed between the hepatocytes, which represent the sinusoids and are lined with endothelial cells, as shown in Figure 1.

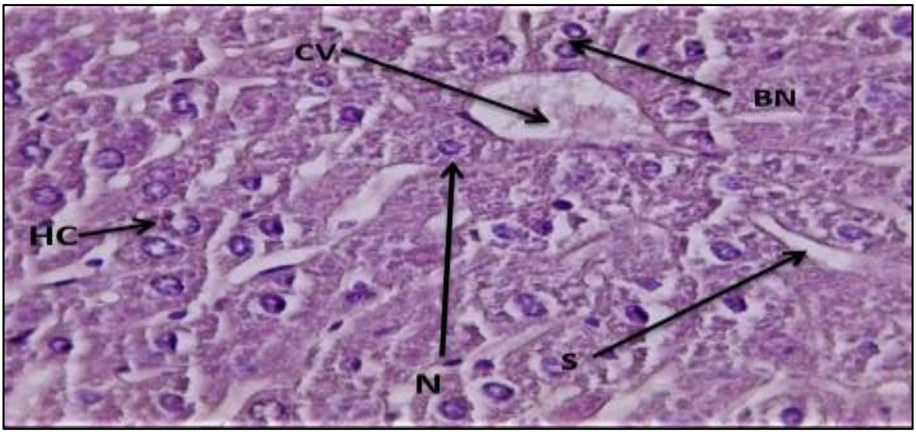

Figure 1 Section of the liver of the control group showing the histological structure of the liver. Note: (CV) central vein, (HC) hepatocyte, (BN) binucleated hepatocyte, (S) sinusoids. Stained (H&E), ×40

Histological changes in Mouse Liver injected by 0.6 mg Rybelsus drug: The results of microscopic examination of liver sections in the experimental groups dosed with 0.6 mg of Rybelsus drug showed that there were negative effects resulting from the drug where some tissue changes, the most important of which was the appearance of congestion in the central vein and the expansion of some hepatic sinusoids, while the cells maintained their arrangement in the form of hepatic cords around the central vein, as shown in Figure 2.

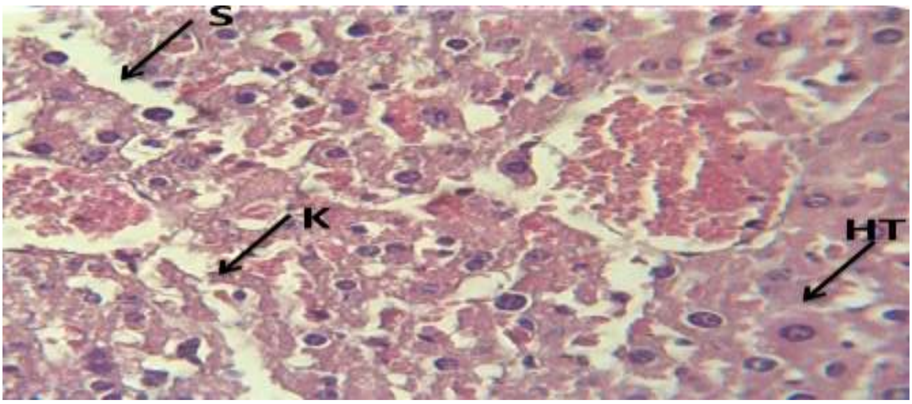

Figure 2 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, showing the occurrence of dilatation of sinusoids (S), increased numbers of Kupffer cells (K), and hypertrophy (HT) of hepatocytes, stained (H & E), ×40

Also, there were some histological changes shows vascular congestion in the portal vein and its expansion, and an increase in the number of ducts in the bile duct cells as shown in Figure 3.

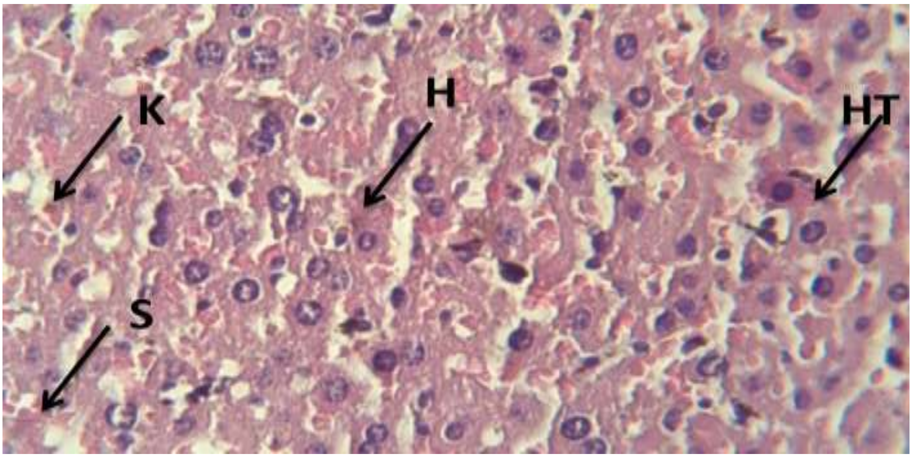

Figure 3 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, note: scattered hepatocytes (H), Kupffer cells (K), sinusoids (S), cell hyperplasia (HT), stained (H&E), 40×.

The presence of some histological changes, blood congestion in the portal vein, thickening of the nuclei, fibrosis, necrosis of liver cells as shown in Figure 4 and 5 and the scattering of hepatocytes, Kupffer cells, and sinusoids as shown in Figure 6.

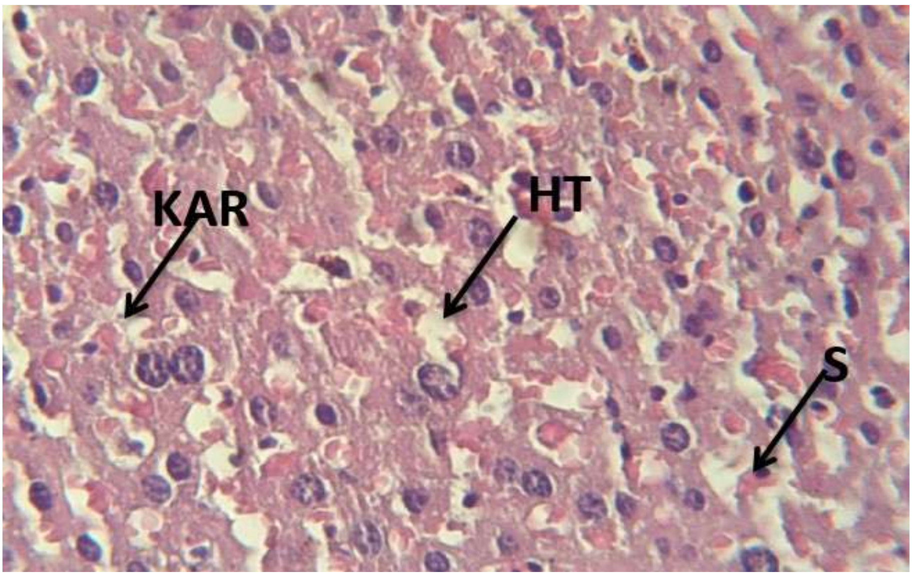

Figure 4 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days. Note: hepatocyte hypertrophy (HT), nuclei hypertrophy (KAR), Kupffer cells (K), sinusoids (S, stained (H & E) 40×

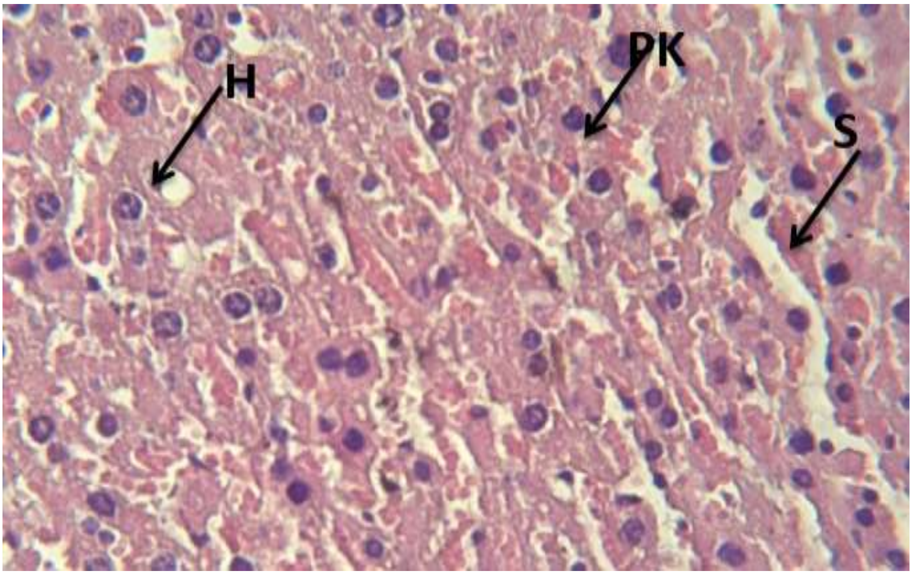

Figure 5 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, note: thickening of the nuclei (PK), hepatocytes (H), sinusoids (S), stained (H & E), 40×.

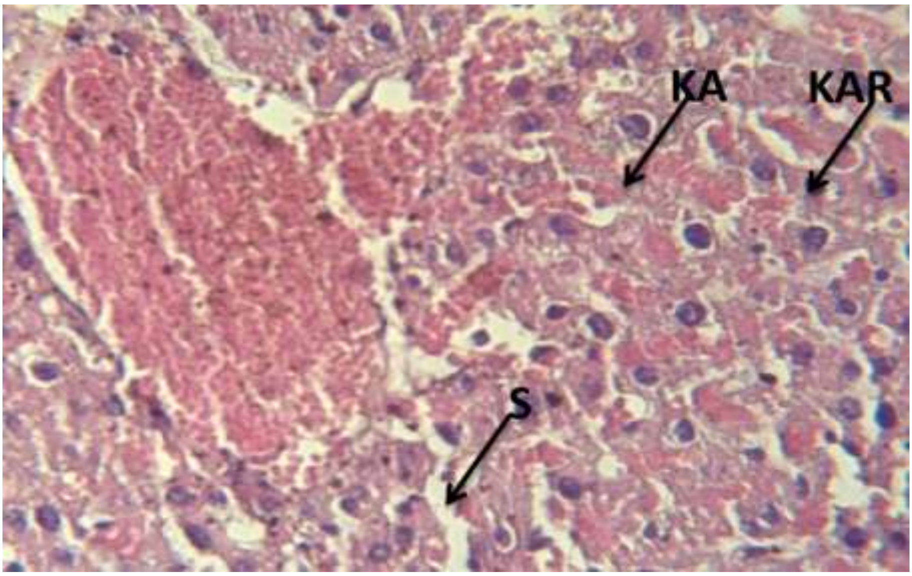

Figure 6 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, note: nuclei degeneration (KA), nuclei enlargement (KAR), sinusoids (S), stained (H & E), 40×.

Cytological alterations were also observed in the liver tissue represented by the enlargement of some hepatocytes (hypertrophy), and the enlargement of their nuclei (karyomegaly) as shown in Figure 7.

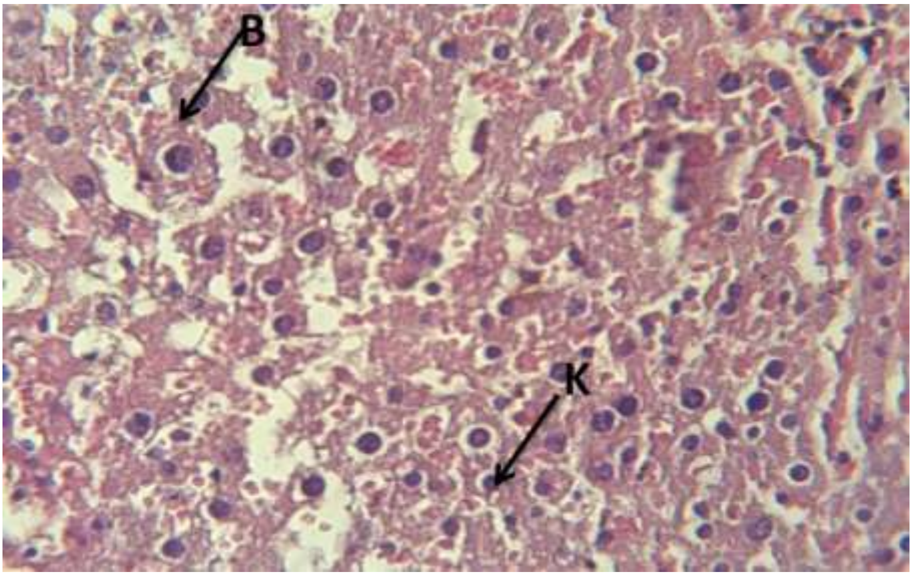

Figure 7 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, note: edematous degeneration (B), stained (H & E), 40×.

Pyknosis of the nuclei of some hepatocytes was also observed, as they appeared in a dark color and small size in the center of the cells, and the expansion of the sinusoids. Karyolysis of the nuclei of some hepatocytes was also observed, as the nuclei completely disappeared, and the cell was seen in a uniform color 8.

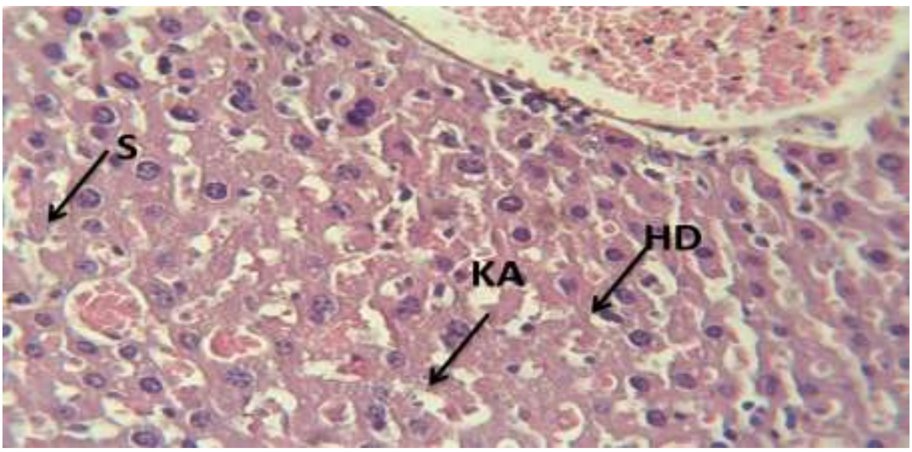

Figure 8 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, note: hilar degeneration (HD), nucleolar degeneration (KA), sinusoids (S), stained (H & E), 40×

Treatment with Rybelsus also caused damage to the central vein, as its normal circular shape changed to an irregular, elongated oval shape, and congestion was observed in it 9(Figure 28-4). Infiltration of inflammatory cells (mononuclear cells) was also seen in the liver parenchyma 10(Figure 29-4).

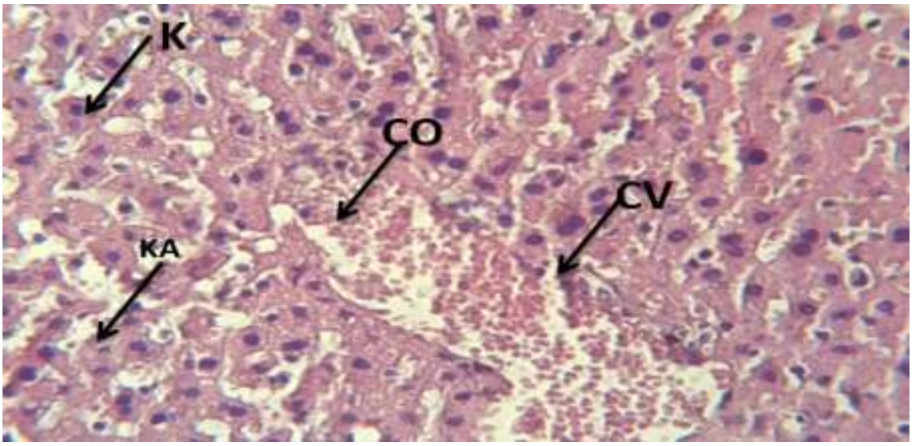

Figure 9 Liver section of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, note: damage and elongation of the central vein (CV), congestion (CO), nucleolar lysis (KA), Kupffer cells (K), stained (H & E), 40×

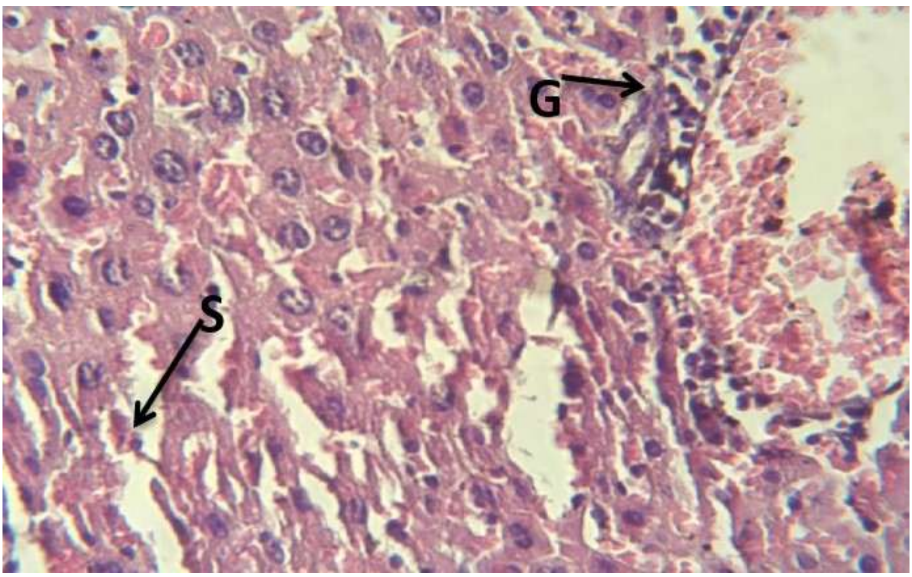

Figure 10 Section of the liver of experimental group mice treated with Rybelsus at a concentration of 0.6 mg/day for 30 days, note: occurrence of granulation (G), sinusoids (S), stained (H & E), 40×

Effect of Rybelsus on the histological structure of the Liver: Pyknosis was observed in some hepatocyte nuclei, as the nuclei appeared dark in color and smaller compared to the control group. This result is not consistent with what was indicated by (Inia et al., 2023) that nuclei thickening usually occurs when the cell undergoes necrosis after a cellular injury resulting from a toxic substance, and is represented by swelling degeneration, after which the cell condenses the chromatin and then thickens it. The cause of degeneration and enlargement of hepatocytes, thickening and decomposition of the nuclei may be Rybelsus treatment and its occurrence of clear tissue damage in hepatocytes that affected the normal shape of the liver. In addition to the damage in the hepatocytes that appeared in the current result, Rybelsus affected the sinusoids in terms of the appearance of dilation in them compared to the control group. The deficiency in venous blood flow and central vein occlusion work to cause an increase or congestion in venous pressure, which leads to dilation of the sinusoids. Congestion was also observed in the central and portal veins in this result in the Rybelsus treatment group compared to the control group, as there was clear blood pooling in these vessels, and this does not agree with what they indicated (Zhang et al., 2020), as they showed that the deficiency in blood flow causes congestion in the blood vessels and liver parenchyma.

Bile duct proliferation in the liver of male white mice in the present results, a hepatic cellular reaction that led to hyperplasia of bile duct cells caused hyperplasia of bile duct cells or what is called Noecholangioles. As a result of the toxicity of foreign external substances, an increase in the number of bile duct cells occurs. The reason for the occurrence of the phenomenon of hyperplasia of bile ducts in this study may be the toxicity of the drug as a foreign substance to the body, which leads to a hepatic reaction leading to hyperplasia.

Conclusions

Injecting mice with Rybelsus for 30 days caused several noticeable changes in the liver. This drug had a toxic effect that led to tissue changes in the liver of mice after injection. In addition, there was a change in the diameters of both the central vein and the portal vein in the liver when compared with the control group.

References

1. Abbas, M.N., & Abbas, F. S. (2013a). Iraqi Rice Husk Potency to Eliminate Toxic Metals from Aqueous Solutions and Utilization from Process Residues", Advances in Environmental Biology, 7(2), 308-319, ISSN 1995-0756.
2. Ali, S.A.K., Almhana, N.M., Hussein, A.A., & Abbas, M.N. (2020a). Purification of Aqueous Solutions from Toxic Metals using Laboratory Batch Mode Adsorption Unit Antimony (V) Ions as a Case Study. Journal of Green Engineering (JGE), 10(11), 10662-10680.
3. Abbas, M.N., Al-Tameemi, I.M., Hasan, M.B., & Al-Madhhachi, A.T. (2021). Chemical Removal of Cobalt and Lithium in Contaminated Soils using Promoted White Eggshells with Different Catalysts. South African Journal of Chemical Engineering, 35, 23-32. https://doi.org/10.1016/j.sajce.2020.11.002

4. Maddodi, S.A., Alalwan, H.A., Alminshid, A.H., & Abbas, M.N. (2020). Isotherm and computational fluid dynamics analysis of nickel ion adsorption from aqueous solution using activated carbon. South African Journal of Chemical Engineering, 32, 5-12. https://doi.org/10.1016/j.sajce.2020.01.002
5. Abbas, M.N., & Abbas, F.S., (2013b). The Predisposition of Iraqi Rice Husk to Remove Heavy Metals from Aqueous Solutions and Capitalized from Waste Residue. Research Journal of Applied Sciences, Engineering and Technology, 6(22), 4237-4246.
6. Alalwan, H.A., Mohammed, M.M., Sultan, A.J., Abbas, M.N., Ibrahim, T.A., Aljaafari, H.A.S., & Alminshid, A.A. (2021). Adsorption of methyl green stain from aqueous solutions using non-conventional adsorbent media: Isothermal kinetic and thermodynamic studies. Bioresource Technology Reports, 14, 100680. https://doi.org/10.1016/j.biteb.2021.100680
7. Alalwan, H.A., Abbas, M.N., & Alminshid, A.H. (2020). Uptake of Cyanide Compounds from Aqueous Solutions by Lemon Peel with Utilising the Residue Absorbents as Rodenticide. Indian Chemical Engineer, 62(1), 40-51 https://doi.org/10.1080/00194506.2019.1623091
8. Abbas, M.N., & Abbas, F.S. (2014). Application of Rice Husk to Remove Humic Acid from Aqueous Solutions and Profiting from Waste Leftover. WSEAS Transactions on Biology and Biomedicine, 11, 62-69.
9. Alhamd, S.J., Abbas, M.N., Manteghian, M., Ibrahim, T.A., & Jarmondi, K.D.S. (2024a). Treatment of Oil Refinery Wastewater Polluted by Heavy Metal Ions via Adsorption Technique using Non-Valuable Media: Cadmium Ions and Buckthorn Leaves as a Study Case. Karbala International Journal of Modern Science, 10(1), 1-18. https://doi.org/10.33640/2405-609X.3334
10. Alalwan, H.A., Abbas, M.N., Abudi, Z.N., & Alminshid, A.H. (2018). Adsorption of thallium ion (Tl^{+3}) from aqueous solutions by rice husk in a fixed-bed column: Experiment and prediction of breakthrough curves. Environmental Technology and Innovation, 12, 1-13. https://doi.org/10.1016/j.eti.2018.07.001
11. Ibrahim, S.A., Hasan, M.B., Al-Tameemi, I.M., Ibrahim, T.A., & Abbas, M.N. (2021). Optimization of adsorption unit parameter of hardness remediation from wastewater using low-cost media. Innovative Infrastructure Solutions, 6(4), Article No. 200. https://doi.org/10.1007/s41062-021-00564-3
12. Ali, G.A.A., Ibrahim, S.A., & Abbas, M.N. (2021). Catalytic Adsorptive of Nickel Metal from Iraqi Crude Oil using non-Conventional Catalysts. Innovative Infrastructure Solutions, 6, Article No.: 7, 9 pages. https://doi.org/10.1007/s41062-020-00368-x
13. Ibrahim, T.A., Mahdi, H.S., Abbas, R.S., & Abbas, M.N. (2020a). Study the Effect of Ribavirin Drug on the histological structure of the testes in Albino mice (Mus musculus). Journal of Global Pharma Technology, 12(02 Suppl.), 142-146.
14. Ibrahim, T.A., Mohammed, A.M., Abd ali, I.K., & Abbas, M.N., Hussien, S.A. (2020b). Teratogenic Effect of Carbamazepine Drug on the Histological Structure of Testes in the Albino Mouse (Mus musculus). Indian Journal of Forensic Medicine & Toxicology, 14(4), 1829-1834 https://doi.org/10.37506/ijfmt.v14i4.11809
15. Abbas, M.N., Al-Madhhachi, A.T., & Esmael, S.A. (2019a). Quantifying soil erodibility parameters due to wastewater chemicals. International Journal of Hydrology Science and Technology, 9(5), 550-568. http://doi.org/10.1504/IJHST.2019.10016884
16. Hameed, W.A., & Abbas M. N. (2024). Dyes Adsorption from Contaminated Aqueous Solution Using Silicon Dioxide Nanoparticles Prepared from Extracted Tree Leaves. Journal of Ecological Engineering, 25(7), 41-57. https://doi.org/10.12911/22998993/187921
17. Abd ali, I.K., Ibrahim, T.A., Farhan, A.D., & Abbas, M. N. (2018). Study of the effect of pesticide 2,4-D on the histological structure of the lungs in the albino mice (Mus musculus). Journal of Pharmaceutical Sciences and Research, 10(6), 1418-1421.

18. Abbas, M.N., Al-Hermizy, S.M.M., Abudi, Z.N., & Ibrahim, T.A. (2019b). Phenol Biosorption from Polluted Aqueous Solutions by Ulva lactuca Alga using Batch Mode Unit. Journal of Ecological Engineering, 20(6), 225-235. https://doi.org/10.12911/22998993/109460
19. Ghulam, N.A., Abbas, M.N., & Sachit, D.E. (2020). Preparation of synthetic alumina from aluminium foil waste and investigation of its performance in the removal of RG-19 dye from its aqueous solution. Indian Chemical Engineer, 62(3), 301-313. https://doi.org/10.1080/00194506.2019.1677512
20. Abbas, M.N., & Abbas, F.S. (2013c). The Feasibility of Rice Husk to Remove Minerals from Water by Adsorption and Avail from Wastes. WSEAS Transactions on Environment and Development, 9(4), 301-313
21. Ali, S.A.K., Abudi, Z.N., Abbas, M.N., Alsaffar, M.A., & Ibrahim, T.A. (2024). Synthesis of Nano-silica Particles using Eucalyptus globulus Leaf Extract and Their Innovative Application as an Adsorbent for Malachite Green Dye. Russian Journal of Applied Chemistry, 97(1), 2-14. https://doi.org/10.1134/S1070427224010099
22. Al-Hermizy, S.M.M., Al-Ali, S.I.S., Abdulwahab, I.A., & Abbas, M.N. (2022). Elimination of Zinc Ions (Zn^{+2}) from Synthetic Wastewater Using Lemon Peels. Asian Journal of Water, Environment and Pollution, 19(5), 79-85. https://doi.org/10.3233/AJW220073
23. Ali, S.T., Qadir, H.T., Moufak, S.K., Al-Badri, M.A.M., & Abbas, M.N. (2020b). A Statistical Study to Determine the Factors of Vitamin D Deficiency in Men the City of Baghdad as a Model. Indian Journal of Forensic Medicine & Toxicology, 14(1), 691-696. https://doi.org/10.37506/ijfmt.v14i1.132
24. Khaleel, L.R., Al-Hermizy, S.M.M., & Abbas, M.N. (2022). Statistical Indicators for Evaluating the Effect of Heavy Metals on Samaraa Drug Industry Water Exposed to the Sun and Freezing. Tropical Journal of Natural Product Research, 6(12), 1969-1974. http://www.doi.org/10.26538/tjnpr/v6i12.12
25. Hashem, N.S., Ali, G.A.A., Jameel, H.T., Khurshid, A.N., & Abbas, M.N. (2021). Heavy Metals Evaluation by Atomic Spectroscopy, for Different Parts of Water Hyacinth (Eichhornia crassipes) Plants Banks of Tigris River. Biochemical and Cellular Archives, 21(2), 3813-3819, https://connectjournals.com/03896.2021.21.3813
26. Hasan, M.B., Al-Tameemi, I.M., & Abbas, M.N. (2021). Orange Peels as a Sustainable Material for Treating Water Polluted with Antimony. Journal of Ecological Engineering, 22(2), 25-35. https://doi.org/10.12911/22998993/130632
27. Abbas, M.N., Ali, S.T., & Abbas, R.S. (2020). Rice Husks as a Biosorbent Agent for Pb^{+2} Ions from Contaminated Aqueous Solutions: A Review. Biochemical and Cellular Archives, 20(1), 1813-1820. https://doi.org/10.35124/bca.2020.20.1.1813
28. Alhamd, S.J., Abbas, M.N., Al-Fatlawy, H.J.J., Ibrahim, T.A., Abbas, Z.N. (2024b). Removal of phenol from oilfield produced water using non-conventional adsorbent medium by an eco-friendly approach. Karbala International Journal of Modern Science, 10(1), 1-18. https://doi.org/10.33640/2405-609X.3350
29. Abdulkareem, W.S., Aljumaily, H.S.M., Mushatat, H.A., Abbas, M.N. (2023). Management of Agro-Waste by Using as an Additive to Concrete and Its Role in Reducing Cost Production: Impact of Compressive Strength as a Case Study. International Journal on "Technical and Physical Problems of Engineering" (IJTPE), 15(1), 62-67
30. Hamdi, G.M., Abbas, M.N., & Ali, S.A.K. (2024). Bioethanol Production from Agricultural Waste: A Review. Journal of Engineering and Sustainable Development, 28(2), 233–252. https://doi.org/10.31272/jeasd.28.2.7

31. Abbas, M.N., Ibrahim, S.A., Abbas, Z.N., Ibrahim, T.A. (2022a). Eggshells as a Sustainable Source for Acetone Production", Journal of King Saud University - Engineering Sciences, 34(6), 381-387. https://doi.org/10.1016/j.jksues.2021.01.005
32. Abd Al-Latif, F.S., Ibrahim, T.A., & Abbas, M.N. (2023). Revealing Potential Histological Changes of Deltamethrin Exposure on Testicular Tissue in Albino Rabbits (Oryctolagus cuniculus). Advancements in Life Sciences, 10(4), 619-626.
33. Abbas, M.N. (2015). Phosphorus removal from wastewater using rice husk and subsequent utilization of the waste residue. Desalination and Water Treatment, 55(4), 970-977. https://doi.org/10.1080/19443994.2014.922494
34. Abbas, M.N., & Alalwan, H.A. (2019). Catalytic Oxidative and Adsorptive Desulfurization of Heavy Naphtha Fraction. Korean Journal of Chemical Engineering, 12(2), 283-288. http://doi.org/10.9713/kcer.2019.57.2.283
35. Alminshid, A.H., Abbas, M.N., Alalwan, H.A., Sultan, A.J., & Kadhome, M.A. (2021). Aldol condensation reaction of acetone on MgO nanoparticles surface: An in-situ drift investigation. Molecular Catalysis, 501, 111333. https://doi.org/10.1016/j.mcat.2020.111333
36. Abbas, F.S., Abdulkareem, W.S., & Abbas, M.N. (2022b). Strength Development of Plain Concrete Slabs by the Sustainability Potential of Lead-Loaded Rice Husk (LLRH). Journal of Applied Engineering Science, 20(1), 160-167. https://doi:10.5937/jaes0-32253
37. Rajaa, N., Kadhim, F.J., Abbas, M.N., Banyhussan, Q.S. (2023). The improvement of concrete strength through the addition of sustainable materials (agro-waste loaded with copper ions). 3rd International Conference for Civil Engineering Science (ICCES 2023), IOP Conf. Series: Earth and Environmental Science, 1232, 012038, 9 Pages. http://doi.org/10.1088/1755-1315/1232/1/012038
38. Abdullah, W.R., Alhamadani, Y.A.J., Abass, I.K., & Abbas, M.N. (2023). Study of chemical and physical parameters affected on purification of water from inorganic contaminants. Periodicals of Engineering and Natural Sciences, 11(2), 166-175. http://dx.doi.org/10.21533/pen.v11i2.3508
39. Alwan, E.K., Hammoudi, A.M., Abd, I.K., Abd Alaa, M.O., & Abbas, M.N. (2021). Synthesis of Cobalt Iron Oxide Doped by Chromium Using Sol-Gel Method and Application to Remove Malachite Green Dye. NeuroQuantology, 19(8), 32-41 http://doi:10.14704/nq.2021.19.8.NQ21110
40. Rippe, J.M. (2018). Lifestyle Medicine: The Health Promoting Power of Daily Habits and Practices. American journal of lifestyle medicine, 12(6), 499–512. https://doi.org/10.1177/1559827618785554
41. Ali, G.A.A., & Abbas, M.N. (2020). Atomic Spectroscopy Technique Employed to Detect the Heavy Metals from Iraqi Waterbodies Using Natural Bio-Filter (Eichhornia crassipes) Thera Dejla as a Case Study. Systematic Reviews in Pharmacy, 11(9), 264-271. https://doi.org/10.31838/srp.2020.9.43
42. Ryan, D.H. (2021). Next Generation Antiobesity Medications: Setmelanotide, Semaglutide, Tirzepatide and Bimagrumab: What do They Mean for Clinical Practice?. Journal of obesity & metabolic syndrome, 30(3), 196–208. https://doi.org/10.7570/jomes21033
43. Al-Ali, S.I.S., Abudi, Z.N., & Abbas, M.N. (2023). Modelling and Simulation for the use of Natural Waste to Purified Contaminated Heavy Metals. Journal of the Nigerian Society of Physical Sciences, 5(1), 1143. https://doi.org/10.46481/jnsps.2023.1143
44. Lean, M.E.J., Astrup, A., & Roberts, S.B. (2018). Making progress on the global crisis of obesity and weight management. BMJ (Clinical research ed.), 361, k2538. https://doi.org/10.1136/bmj.k2538

45. Abbas, M.N., & Nussrat, T.H. (2020). Statistical Analysis of Experimental Data for Adsorption Process of Cadmium by Watermelon Rinds in Continuous Packed Bed Column. International Journal of Innovation, Creativity and Change, 13(3), 124-138.
46. Cohen, J.B., & Gadde, K.M. (2019). Weight Loss Medications in the Treatment of Obesity and Hypertension. Current hypertension reports, 21(2), 16. https://doi.org/10.1007/s11906-019-0915-1
47. Curthoys, N.P., & Moe, O.W. (2014). Proximal tubule function and response to acidosis. Clinical journal of the American Society of Nephrology : CJASN, 9(9), 1627–1638. https://doi.org/10.2215/CJN.10391012
48. Abbas, M.N., & Ibrahim S.A. (2020). Catalytic and thermal desulfurization of light naphtha fraction", Journal of King Saud University - Engineering Sciences, 32(4), 229-235. https://doi.org/10.1016/j.jksues.2019.08.001
49. Williams, L.T., Barnes, K., Ball, L., Ross, L.J., Sladdin, I., & Mitchell, L.J. (2019). How Effective Are Dietitians in Weight Management? A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Healthcare (Basel, Switzerland), 7(1), 20. https://doi.org/10.3390/healthcare7010020
50. Brewis, A., & Trainer, S. (2024). No 'easy' weight loss: don't overlook the social cost of anti-obesity drugs. Nature, 626(7998), 258–260. https://doi.org/10.1038/d41586-024-00329-9
51. Iijima, T., Shibuya, M., Ito, Y., & Terauchi, Y. (2023). Effects of switching from liraglutide to semaglutide or dulaglutide in patients with type 2 diabetes: A randomized controlled trial. Journal of diabetes investigation, 14(6), 774–781. https://doi.org/10.1111/jdi.14000
52. Stafeev, I., Agareva, M., Michurina, S., Tomilova, A., Shestakova, E., Zubkova, E., Sineokaya, M., Ratner, E., Menshikov, M., Parfyonova, Y., & Shestakova, M. (2024). Semaglutide 6-months therapy of type 2 diabetes mellitus restores adipose progenitors potential to develop metabolically active adipocytes. European journal of pharmacology, 970, 176476. https://doi.org/10.1016/j.ejphar.2024.176476
53. Tan, X., Liang, Y., Gamble, C., & King, A. (2024). Durability of Effectiveness Between Users of Once-Weekly Semaglutide and Dipeptidyl Peptidase 4 Inhibitors (DPP-4i) in US Adults with Type 2 Diabetes. Diabetes therapy : research, treatment and education of diabetes and related disorders, 15(2), 427–445. https://doi.org/10.1007/s13300-023-01509-y
54. Karásek D. (2022). Oral semaglutide - Rybelsus®, the first GLP-1 receptor agonist for oral use in clinical practice. Orální semaglutid - Rybelsus®, první agonista GLP-1 receptoru pro perorální použití v klinické praxi. Vnitrni lekarstvi, 68(2), 89–95.
55. Andersen, A., Knop, F.K., & Vilsbøll, T. (2021). A Pharmacological and Clinical Overview of Oral Semaglutide for the Treatment of Type 2 Diabetes. Drugs, 81(9), 1003–1030. https://doi.org/10.1007/s40265-021-01499-w
56. Rubino, D.M., Greenway, F.L., Khalid, U., O'Neil, P.M., Rosenstock, J., Sørrig, R., Wadden, T.A., Wizert, A., Garvey, W.T., & STEP 8 Investigators (2022). Effect of Weekly Subcutaneous Semaglutide vs Daily Liraglutide on Body Weight in Adults with Overweight or Obesity without Diabetes: The STEP 8 Randomized Clinical Trial. JAMA, 327(2), 138–150. https://doi.org/10.1001/jama.2021.23619
57. Shaman, A.M., Bain, S.C., Bakris, G.L., Buse, J.B., Idorn, T., Mahaffey, K.W., Mann, J.F.E., Nauck, M.A., Rasmussen, S., Rossing, P., Wolthers, B., Zinman, B., & Perkovic, V. (2022). Effect of the Glucagon-Like Peptide-1 Receptor Agonists Semaglutide and Liraglutide on Kidney Outcomes in Patients with Type 2 Diabetes: Pooled Analysis of SUSTAIN 6 and LEADER. Circulation, 145(8), 575–585. https://doi.org/10.1161/CIRCULATIONAHA.121.055459

58. Abd Ali, I.K., Salman, S.D., Ibrahim, T.A., & Abbas, M.N., (2024). Study of the Teratogenic Effects of Antimony on Liver in the Adult Rabbit (Oryctolagus cuniculus). Advancements in Life Sciences, 11(2), 462-469.
59. Suvarna, S.K.; Layton, L., & Bancroft, J.D. (2019). Bancroft's theory and practice of histlogical techniques, 7th ed. Churchill Livingstone Elsevier Ltd., Shanghai, China: pp 609.
60. Inia, J.A., Stokman, G., Morrison, M.C., Worms, N., Verschuren, L., Caspers, M.P.M., Menke, A.L., Petitjean, L., Chen, L., Petitjean, M., Jukema, J. W., Princen, H.M.G., & van den Hoek, A.M. (2023). Semaglutide Has Beneficial Effects on Non-Alcoholic Steatohepatitis in Ldlr-/-.Leiden Mice. International journal of molecular sciences, 24(10), 8494. https://doi.org/10.3390/ijms24108494
61. Zhang, N., Tao, J., Gao, L., Bi, Y., Li, P., Wang, H., Zhu, D., & Feng, W. (2020). Liraglutide Attenuates Nonalcoholic Fatty Liver Disease by Modulating Gut Microbiota in Rats Administered a High-Fat Diet. BioMed research international, 2020, 2947549. https://doi.org/10.1155/2020/2947549