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Assessment of Querectin Influence on Multiple Physiological, Biochemical and Immunological Parameters in Diabetic Rats

Sara Saeb Rasheed[1], Rawnaq Z. Fadhil[1], Salah M.M. AL-Chalabi[1], Rawaa Adnan Khalaf[1], Ferial A. Al Mahdawi[2], Ahmed Flayyih Hasan[1]

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ABSTRACT

Background: Diabetes is a worldwide disease threatens a large number of the human population due to their complication which extended to almost all body organs. Recently querectin were studied to their pharmaceutical activities.

Methods: Therefore this paper studied the effect of querectin on multiple physiological, biochemical and immunological markers for diabetic rats supplemented with querectin 150 m/k orally for 30 days.

Result: the result revealed that lipid profile improved in treated rats in-compared to untreated groups as cholesterol result was 176±3.09 mg/dl versus 210±5.2 mg/dl in the untreated group, triglyceride 150.3±2.85 mg/dl versus 176±4.30 mg/dl, high density lipoprotein result was 37.42±2.9 mg/dl versus 24.43±3.2 mg/dl, low density lipoprotein 109.59±6.85 mg/dl versus 151.29±5.70 mg/dl and very low density lipoprotein (30.45±2.90 versus 35.20±3.52) mg/dl in P value ≤0.01. In addition, glucose level was gradually reduced in treated group against non-treated one (200.43±1.96, 320±2.85) mg/dl. Urea and creatinine level was restored in quarectin treated rats (29.50±2.43, 0.96±0.06) mg/dl respectively in compared to diabetic untreated rats (37.54±3.53, 1.6±0.05) mg/dl. Immunological parameters including TNF-α, IL-1, IL-6 and C-reactive protein (CRP) showed a significant reduction in comparison to untreated rats (2.48±0.39, 4.70±1.22) for TNF-α, (4.38±1.59, 7.69±1.32) for IL-1, (3.24±0.12, 5.05±1.42) and (4.60±0.53, 5.05±0.54) for CRP. Similar results was shown in lactate dehydrogenase (157.54±3.65, 17.54±3.32) for treated and non treated rats respectively, anti-oxidant parameters were measured and te results were catalase significantly restored in treated group (10.30±2.76, 13.70±2.63), super oxide dismutase (7.13±2.67, 9.94±2.94) and malondialhdeyde (2.90±0.39, 4.89±0.48) in a P value ≤0.05.

Key words: Anti-diabetic, Anti-inflammatory, Anti-oxidant, Diabetes, Querectin.

INTRODUCTION

Quercetin is a potent natural compound found in fruits, vegetables, flowers and other plants, numerous studies have shown that this component has valuable therapeutic potential for both prevention and treatment numerous disease due to anti-oxidant, anti-diabetic, antimicrobial, anti-cancerous and anti-inflammatory properties (Yan *et al.,* 2023). Quercetin has significant anti-diabetic influence that help in reducing blood sugar and elevating insulin sensitivity, thus had been demonstrated to influence various factors and signaling pathways involved in insulin resistance and the development of type2 diabetes (Dhanya *et al.,* 2022; Al-Khuzaay *et al*., 2024). As well as, this compound capable of preventing and reduction the diabetic complication including cardiovascular, neuropathy, delayed wound healing and diabetic nephropathy by targeting the key mechanisms involved in pathogenesis of these complications (Ansari *et al.,* 2006; Yahya *et al*., 2024). The antioxidant activities of querectin relay on free radicals and their ability to reduce lipid peroxidation moreover; it has also been proven to up regulate antioxidant level (Rahmani *et al.,* 2023; Abd El-Rahmana *et al*., 2024). The oxidative stress is a key role in diabetes and considerd as the causative of cellular disturbance in kidney and causes vascular permeability enhancement then tissue damage, beside it has been recognized as a factor in the pathogenesis and progression (Mehany *et al.,* 2006).

[1]Biotechnology Research Center, Al-Nahrain University, Baghdad, Iraq.
[2]Department of Biology, Al-Farabi University College, Baghdad, Iraq.

Corresponding Author: Ahmed Flayyih Hasan, Biotechnology Research Center, Al-Nahrain University, Baghdad, Iraq.
Email: ahmed_flayyih@nahrainuniv.edu.iq
ORCID: 0009-0007-9208-5046

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Furthermore, this agent capable of reducing kidney damage(one of the main complication in diabetes) through the maintenance of kidney structure. The histological studies of kidney in diabetic rats found congestion, fibrosis and deposition of collagen fiber and infiltration of lymphocytes demonstrating kidney damage. Whereas pathological changes of the kidney tissue in the diabetic group that received quercetin showed less damage and reduced fibrosis when compared with diabetes control group (Yanowsky-escatell *et al.,* 2020).

Polyphenols has been shown to have anti-inflammatory and anti-apoptotic effects by reducing the production of pro-inflammatory cytokines (TNF-α, IL-1, IL-6, CRP) and other inflammatory molecules (Wang *et al.,* 2022; Hameed *et al.,* 2024). Flavonoid reduce lactate concentrations that increase ROS (reactive oxygen species) and lipid peroxidase production which in turn lead to NF-Kf (nuclear factor kappa-beta) activation and increased VEGF(vascular endothelial growth factor) and VEGF2 protein concentration which subsequently elevates migration and production of (IL-8) and other cytokines that control the oxidative stress.

This role of querecetin on lactate highlighted the anti-carcinogenic properties due to Warburg effect when the most cancer cells would rather to use glycolytic pathway extensively to produce energy rather than Krebs cycle (Tura *et al.,* 2024).

This study aimed to assess the role of querectin on diabetes disease and the complications related to it.

MATERIALS AND METHODS

30 albino male rats weighing (160-180) grams were used in this study, divided into three groups each group contains 10 rats as shown below:

Group name	Treating plane
G1: Negative control ©	Healthy untreated rats
G2: Positive control (p)	Diabetes induced by alloxan without any treatment
G3: Treated group (t)	Diabetic rats inducaed by alloxan treated with querecten (150 mg\kg) orally as a single dose for 30 days

Induction of diabetes

Alloxan monohydrate (90 mg\kg) (BDH chemicals\England) with a single dose was used to stimulate diabetes in overnight fasting rats. A 5 ml of glucose solution was given to the rats immediately after treatment. Subsequently the rats were kept under observation for two days and the level of glucose was measured by using glucometer (Rosmax\ Germany). The rats with blood sugar over 250 mg\dl were considered to be hyperglycemic Al Chalabi *et al.,* 2020).

Sample preparation

All samples (blood) were collected under anaesthetized condition, centrifuged at 3000 r.p.m for 10 min, the serum was used for further analyses. Included lipids profile, LDH, MDA, CRP, CAT, SOD, TNF-α, IL-1, IL 6, creatinine and blood urea.

Lipid profile measurement

Serum cholesterol, triglycerides, HDL, concentrations were measured using a diagnostic kit produced by BiolaboSABy based on the reading of the optical intensity of the colored compound using a spectrophotometer at a wavelength of 500 nanometers except for HDL the wavelength was 505 nm.

Kidney function measurement

Both Urea and creatinine was measured in the serum by spinreact (Hasan *et al.,* 2024).

Pro-inflammatory cytokine (IL-1,6 and TNF-α) measurement

Enzyme linked immunosorbent assay form Elabscince was used to measure the cytokines according to manufacturing instructions ,the measurement wasvelength was 450 nm.

LDH measurment

LDH activity was measured *via* the COBAS INTEGRA SYSTEM with cassette which identifies the activity of lactate dehydrogenase enzyme by measuring the absorbance at a wave length of 340 nm.

CRP measurement

C-reactive protein was measured by spinreact.

SOD and CAT measurement

SOD was detected using colorimetric assay kit (hydroxylamine method) from Elabscience and by following the instructions of the kit the yielded activity was expressed as U/ml.

MDA measurement

Malondialdwhyde (MDA) was evaluated by a colorimetric method through the measurement of thiobarbituric acid reactive species in elevated temperature at a wavelength of 532 nm.

Statistical analysis

Mean± standard de*via*tion represents the statistical analysis of all data by student t test grap pad prism 8 and the value considered significant of p value ≤0.05.

RESULTS AND DISCUSSION

Results of using quercetin on lipids profile

The results indicated a statistical elevation in cholesterol level at P≤0.05 value in both diabetic (210±5.82) mg\dl and

Table 1: The effect of quercetin on different lipid profiles in diabetic rats.

Group	Mean ± SE (mg/dl)				
	Cholesterol	Triglyceride	HDL	LDL	VLDL
Negative control	145±3.56c	110.76±3.54c	35.79±2.65a	88.00±5.36c	22.43±2.73b
Positive diabetic	210±5.82a	176±4.30a	24.43±3.21b	151.29 ±5.70a	35.20 ±3.52a
Diabetic + quarectine	176±3.09b	150.32±2.85b	37.42±2.90a	109.59±6.85b	30.45±2.90a
p value	14.65**	21.43**	6.21**	12.40**	5.42**

** (P≤0.01)

control group (145±3.56) mg\dl in compared to quercetin treated group (176±3.09) mg\dl (Table 1).

Triglyceride results showed significant variation among the three groups (Table 1), in quercetin treated group TG. level decrease significantly (150.32±2.85) mg\dl in contrast to control groups (negative and positive) (176±4.30, 110.76±3.54) mg\dl subsequently.

Furthermore, HDL level in diabetic induced group decreased statistically in compared to control group (24.43±3.21 mg\dl), while a significant increase in treated one (37.42±2.90 mg\dl).

Considering LDL data, the diabetic group elevated significantly in compares to control(151.29±5.70, 88.00±5.36mg\dl) subsequently, while these fats decreased in quercetin treated group (109.59±6.85mg\dl)

As for very low-density protein fats (VLDL), a significant difference was indicated in all groups as show in Table 1.

Glucose level in Alloxian stimulated group increase statistically reverse to control, meanwhile the level of glucose in quercetin treated group was diminished significantly as it shown in Table 2.

The data reveled an increase in the level of creatinine and blood urea in alloxan induced group (positive control), while their levels decreased in the diabetic group treated with quercetin when we compared it with untreated group, as show in Table 3.

Regarding for the levels of interleukin (1 and 6) our results manifested there was a significant elevation in diabetic induced group when we compared them with both negative and quercetin treated groups. As for tumor necrosis factor the results indicated a statistical increase in alloxan induced group contrasted with negative and treated groups. The results did not show any significant alterations in level of CRP between the different groups. Otherwise, the data showed a statically elevation in the activity of the lactate dehydrogenase enzyme in diabetic group compared to the negative control group, while the enzyme activity decreased in quercetin treated group, as explained in Table 4.

Table 2: The effect of quercetin on glucose level in diabetic rats.

Group	Mean ± SE	
	Glucose (mg\dl) first week	Glucose (mg\dl) Last week
Negative control	90.56±3.05b	95.54±4.02c
Positive diabetic	340.43±4.55a	320±2.85a
Diabetic + quarectin	334±2.69a	200.43±1.96b
LSD value	9.32*	7.16*

* (P≤0.05).

Table 3: Concentration of urea and creatinine concentrations in diabetic rats treated with quercetin.

Group	Mean ± SE	
	B. urea (mg\dl)	Creatinine (mg\dl)
Negative control	20.52±2.08c	0.53±0.02c
Positive diabetic	37.54±3.53a	1.69±0.05a
Diabetic + quarectin	29.50±2.43b	0.95±0.06b
LSD value	5.10*	0.12*

* (P≤0.05).

Estimation of the concentrations of malondialdehyde, CAT and SOD enzymes

The results showed a significant increase in the level of malondialdehyde in the diabetic group (4.89±0.48)mmol/ml compared to the control group (1.50±0.06) mmol/ml.and diabetic group treated with quercetin (2.90±0.39).

With reference to catalase enzyme, the data showed significant elevation in diabetic induced group (13.70±2.63) contrasted to the negative and quercetin treated groups (8.53±1.53, 10.30±2.76) respectively.

Finally, the results showed there was a statistical increase in the level of the superoxide enzyme dismutase in the diabetic group (9.94±2.94) IU/L compared to the control group (4.48±1.34) IU/L and the quercetin treated group (7.13±2.67) IU/liter, as show in Table 5.

Diabetes is a global issue and about three hundred eighty two cases were indicated and this number is projected to increase. As diabetes can affect many organs, major arteries and microvesseles (Yi *et al.,* 2006) thus many studies were carried out in order to solve such condition (Abdel-Tawab *et al.,* 2023). Natural plant contain much active compound whether it was active compound or whole plant, these medicinal plant showed apotent influence on diabetes including querectin (Rahmani *et al.,* 2023). It was mentioned that querectin have the ability to inhabits the absorption of cholesterol in intestine due tote down regulation of epithelial cholesterol transporter neimann pick C1-like1 (NPC1L1), which may explain the reduction in the cholesterol level in treated groups. Another

Table 4: Estimating the level of concentrations of IL1 and IL6, TNF-α, CRP and LDH in animals treated with quercetin.

Groups	Mean ± SE				
	IL1	IL6	TNF-α	CRP	LDH
Negative control	2.74±0.60c	1.80±0.42b	1.57 ±0.05b	4.78±0.89a	124.1 8±4.32c
Positive diabetic	7.69±1.32	5.05±1.42a	4.70±1.22a	5.05±0.54a	178.54±3.32a
Diabetic + quarectine	4.38±1.59	3.24±0.12	2.48±0.39b	4.60±0.53a	157.54±3.65b
LSD value	1.28**	0.73**	1.45**	0.95**	10.50**

*(P≤0.05).

Table 5: Concentrations of malondialdehyde, CAT and SOD enzyme in animals treated with quercetin.

Groups	Mean ± SE		
	MDA	CAT	SOD
Negative control	1.50±0.06cc	8.53±1.53b	4.48±1.34c
Diabetic	4.89±0.48a	13.70±2.63a	9.94±2.94a
Diabetic+ quarectine	2.90±0.39b	10.30±2.76a	7.13±2.67b
LSD value	0.47 **	2.50**	288**

*(P≤0.05).

effect might bedue to flavonoles influence on gut microbiota composition and permeability making querectin a potent hypolipidemic (Tahir *et al.,* 2023), which was proven in the result of LDL, HDL and VLDL above. The lowering effect of triglyceride by querectin is not well known, thought it was suggested that querectin induce the browning of white adipose tissue by up taking the triglyceride from circulation, beside this type of adipose tissue participates in triglyceride metabolism (Kuipers *et al.,* 2018). As well as HDL and VLDL where decreased significantly, while LDL level increased statistically. All together indicate that querectin consumption improve blood lipid profile and further study are required to identify the mechanis of this compound on such parameters.Increasing glucose level in thebody cause a mitochondrial dysfunction and reactive oxygen species generation (Yi *et al.,* 2006). Thus querectin showed a positive effect by lowering the glucose level through inhibiting intestinal absorption of glucose subsequently, the mitochondrial function, ATPase and hexokinase enzymes restoration all together made querectin a potent antioxidant with a promising effect on diabetic patient (Ahmed *et al.,* 2024). Beside it was found that querectin had the ability to increase anti oxidant enzyme and thereby reducing MDA and nitric oxide level (Wang *et al.,* 2023). It is well known tat flavonoid have three-OH which is capable to donate electron and reduce free radicals, all of the above made querectin a candidate as antioxidant factor (Crespo *et al.,* 2008). Many studies indicated a good anti-diabetic effect of querectin as this compound enhance glucose hemostasis, through the restoration of IRS-1 and phophadytelinsitol-3 which mediated glucose uptake by insulin in the brain of diabetic rats. Another influence was found on the liveras querectin stimulate AMPK and there by effecting glucose production from glycogen or production of glycogen from glucose (Yi *et al.,* 2021; Peng *et al.,* 2017). Regarding the influence of querectin consumption on inflammatory cytokine (IL-1, 6, TNF-α) all where reduced significantly. It was suggested that this compound act on leukocyte through targeting multiple enzymes (kinases, phosphetases and membrane proteins) to dominate immune and inflammatory responses (Ansari *et al.,* 2006). Tumor necrosis factor-α is the major stimulator to inflammation, thus its consider one of the most important targets (Nair *et al.,* 2006). Result above indicated a decrease in this cytokine level, suggested that floavonoid querectin compound increased the regulation of peroxisomes proliferated activator (PPAR-γ, which in turn counteract with pro-inflammatory transcriptional factors such as (STAT) and (NF-kβ) as well as decreasing the expressing of TNF-α, IL-1β and IL-6(16). C-reactive protein (CRP) considered as a prototype for inflammatory markers due to: long half-life, absence of variation and its stability. In a consentient study with the present result indicated that querectin showed an anti-inflammatory effect on CRP through lowering their level in the diabetic low insulin rats (Mahmoud *et al.,* 2006). Lactate deydrogenase enzyme , in similar study conducted by Chellian *et al.* (2022) whom used querectin for diabetic rat and mentioned that LDH was reduced in response to querectin attributed to the restored genes of liver function which was been disturbed by diabetes. It was mentioned that genes expression of LDH reduced by querectin (Han *et al.,* 2006; Alyasiri *et al.,* 2024). It is well-known that oxidative stress causing damage in the cells, DNA and proteins of kidney which effect the level of urea and cereatenine, this consider as the major complication of diabetes (Jin *et al.,* 2023; Zhu *et al.,* 2024). It was found that querectin compound act as a checker for renal damage that enhanced by toxicant and participate in reducing pro-inflammatory cytokines and palliated tubular necrosis (Yousuf *et al.,* 2023). Recently it was mentioned that querectin have protective influence on kidney of various models of rodents by prevention the elevation of urea and creatinine levels, as well as maintaining the integrity of kidney by protecting the organ from any histological alteration (Zeng *et al.,* 2023).

CONCLUSION

From the collected data it can be concluded that querectin is an effective compound in treatment of diabetes and its complication. Although, it requires more studies and larger population to ensure their activities.

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Ethics

Approval was obtained from Biotechnology Research Center-Al-Nahrain University of the Animal Health Care Committee.

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Conflict of interest

All authors declared that there is no conflict of interest.

REFERENCES

Abdel-Tawab, Nada H.H., Hassan, H.A., Mohamed, N.M., Hamad, N.H. and Michel, E.F. (2023). Effect of quercetin on diabetic rat. *SVU-International Journal of Medical Sciences*. **6(2):** 708-728.

Abd El-Rahmana, H.A., Hasanb, A.F., Alyasiric, T., El-Wahshd, H.M., Althubyanie, S.A., Basyonyf, M.A. and Mahmodf, D.H. (2024). Co-treatment with cranberry and vitamin-C mitigates reproductive toxicities induced by phenobarbital in male rats. *Cell Physiol Biochem*. **58:** 722-738.

Ahmed, S.F., Bakr, M.A. and Rasmy, A.H. (2024). The efficacy of using metformin and/or quercetin for amelioration of gamma-irradiation induced tongue toxicity in diabetic rats. *BMC Oral Health*. **24(1):** 110.

Al Chalabi, Salah M.M., *et al.* (2020). Benefit effect of ethanolic extract of Bay leaves (*Laura nobilis*) on blood sugar level in adult diabetic rats induced by alloxan monohydrate-J. *Annals of Tropical Medicine and Public Health*. **23(16)**.

Al-Khuzaay, H.M., Al-Juraisy, Y.H., Hasan, A.F. and Tousson, E. (2024). Antitumor activity of β-glucan isolated àrom date fruits щn cancer cells *in vivo*. *Opera Medica et Physiologica*. **11(3):** 41-48.

Alyasiri, T., Hameed, H.M. and Hasan, A.F. (2024). The effects of bisphenol A of polycarbonate plastics on various blood and fertility parameters, along with histological changes in male albino rats. *Asian Journal of Dairy and Food Research*. 1-7. doi: 10.18805/ajdfr.DRF-435.

Ansari, P., Choudhury, S.T., Seidel, V., Rahman, A.B., Aziz, M.A., Richi, A.E. and Abdel-Wahab, Y.H. (2006). Therapeutic potential of quercetin in the management of type-2 diabetes mellitus. *Life*. **12(8):** 1146.

Chellian, R., Behnood-Rod, A., Wilson, R., Lin, K., King, G.W.Y., Ruppert-Gomez, M. and Bruijnzeel, A.W. (2022). Dopamine D1-like receptor blockade and stimulation decreases operant responding for nicotine and food in male and female rats. *Scientific Reports*. **12(1):** 14131.

Crespo, I., Garcia-Mediavilla, M.V., Gutiérrez, B., Sánchez-Campos, S., Tunon, M.J. and González-Gallego, J. (2008). A comparison of the effects of kaempferol and quercetin on cytokine-induced pro-inflammatory status of cultured human endothelial cells. *British Journal of Nutrition*. **100(5):** 968-976.

Dhanya, R. (2022). Quercetin for managing type 2 diabetes and its complications, an insight into multitarget therapy. *Biomedicine and Pharmacotherapy*. **146:** 112560.

Hameed, H.M., Razooki, Z.H., Hasan, A.F., Rasool, A.A.A.A. and Abed, I.J. (2024). Therapeutic effect of essential oils (*Citrus sinensis*) against ehrlich ascites model induced renal toxicity in female mice. *Agricultural Science Digest*. **45(2):** 317-322. doi: 10.18805/ag.DF-632.

Han, J.H., Lee, J., Park, W., Ha, T. and Chung, S. (2006). Natural compounds as lactate dehydrogenase inhibitors: Potential therapeutics for lactate dehydrogenase inhibitors-related diseases. *Frontiers in Pharmacology*. **14**.

Hasan, A.F., Hameed, H.M., Hadid, M.A. and Tousson, E. (2024). Impact of chia (*Salvia hispanica*) seeds extract on ehrlich ascites model induced kidney toxicity in female mice. *Asian Journal of Dairy and Food Research*. **43(4):** 750-756. doi: 10.18805/ajdfr.DRF-397.

Jin, Q., Liu, T., Qiao, Y., Liu, D., Yang, L., Mao, H., Ma, F., Wang, Y., Peng, L. and Zhan, Y. (2023). Oxidative stress and inflammation in diabetic nephropathy: Role of polyphenols. *Frontiers in Immunology*. **14:** 1185317.

Kuipers, E.N., Dam, A.D.V., Held, N.M., Mol, I.M., Houtkooper, R.H., Rensen, P.C. and Boon, M.R. (2018). Quercetin lowers plasma triglycerides accompanied by white adipose tissue browning in diet-induced obese mice. *International Journal of Molecular Sciences*. **19(6):** 1786.

Mahmoud, M.F., Hassan, N.A., El Bassossy, H.M. and Fahmy, A. Quercetin protects against diabetes-induced exaggerated vasoconstriction in rats: Effect on low grade inflammation. *PLOS ONE*. **8(5):** e63784.

Mehany, Ahmed, *et al.* (2006). Biological effect of quercetin in repairing brain damage and cerebral changes in rats: Molecular docking and *in vivo* studies. *BioMed Research International*. **26:** 8962149.

Nair, M.P., Mahajan, S., Reynolds, J.L., Aalinkeel, R., Nair, H., Schwartz, S.A. and Kandaswami, C. (2006). The flavonoid quercetin inhibits proinflammatory cytokine (tumor necrosis factor alpha) gene expression in normal peripheral blood mono-nuclear cells *via* modulation of the NF-κβ system. *Clinical and Vaccine Immunology*. **13(3):** 319-328.

Peng, J., Li, Q., Li, K., Zhu, L., Lin, X., Lin, X. and Xie, X. (2017). Quercetin improves glucose and lipid metabolism of diabetic rats: Involvement of Akt signaling and SIRT1. *Journal of Diabetes Research*. pp. 3417306. doi: 10.1155/2017/3417306.

Rahmani A.H., Alsahli M.A., Khan A.A., Almatroodi S.A. (2023). Quercetin, a plant flavonol attenuates diabetic complications, renal tissue damage, renal oxidative stress and inflammation in streptozotocin-induced diabetic rats. *Metabolites*. **13(1):** 130.

Rahmani, Arshad, H. *et al.* (2023). Quercetin, a plant flavonol attenuates diabetic complications, renal tissue damage, renal oxidative stress and inflammation in streptozotocin-induced diabetic rats. *Metabolites*. **13(1):** 130.

Tahir, Farah N., Asma A., Khadija K. and Rehana B. (2023). Ameliorative effect of quercetin on lipid, enzymatic, hormonal and biochemical profiling of STZ-induced diabetic rats. *Journal of Population Therapeutics and Clinical Pharmacology*. **30(17):** 1950-1967.

Tura, A., Herfs, V., Maaßen, T., Zuo, H., Vardanyan, S., Prasuhn, M., Ranjbar, M., Kakkassery, V., Grisanti, S. (2024). Quercetin impairs the growth of uveal melanoma cells by interfering with glucose uptake and metabolism. *International Journal of Molecular Sciences*. **25(8):** 4292.

Wang, L., Sun, J., Miao, Z., Jiang, X., Zheng, Y., Yang, G. (2022). Quercitrin improved cognitive impairment through inhibiting inflammation induced by microglia in Alzheimer's disease mice. *Neuro Report*. **33:** 327-335.

Wang, T., Wang, Y.Y., Shi, M.Y. and Liu, L. (2023). Mechanisms of action of natural products on type 2 diabetes. *World Journal of Diabetes*. **14(11):** 1603.

Yahya, A., Adil Obaid, W., Mohammed Hameed, O. and Hasan, A.F. (2024). Histopathological and immunohistochemical studies on the effects of silver oxide nanoparticles (AgNPs) on male rats liver. *Journal of Bioscience and Applied Research*. **10(3):** 392-398.

Yan, Lei, *et al.* (2023). Quercetin: An effective polyphenol in alleviating diabetes and diabetic complications. *Critical Reviews in Food Science and Nutrition*. **63(28):** 9163-9186.

Yanowsky-Escatell, Francisco G., *et al.* (2020). The role of dietary antioxidants on oxidative stress in diabetic nephropathy. *Iranian Journal of Kidney Diseases*. **14(2):** 81-94.

Yi, H., Peng, H., Wu, X., Xu, X., Kuang, T., Zhang, J. and Fan, G. (2021). The therapeutic effects and mechanisms of quercetin on metabolic diseases: Pharmacological data and clinical evidence. *Oxidative Medicine and Cellular Longevity*. pp. 6678662. doi: 10.1155/2021/6678662.

Yi, X., Dong, M., Guo, N., Tian, J., Lei, P., Wang, S. and Shi, Y. (2006). Flavonoids improve type 2 diabetes mellitus and its complications: A review. *Frontiers in Nutrition*. **10:** 119 2131.

Yousuf, R., Verma, P.K., Sharma, P., Sood, S., Aït-Kaddour, A. and Bhat, Z.F. (2023). Ameliorative potential of quercetin and catechin against sodium arsenite and mancozeb-induced oxidative renal damage in Wistar rats. *Journal of Trace Elements and Minerals*. **5:** 100079.

Zeng, Y.F., Li, J.Y., Wei, X.Y., Ma, S.Q., Wang, Q.G., Qi, Z. and Tang, H. (2023). Preclinical evidence of reno-protective effect of quercetin on acute kidney injury: A meta-analysis of animal studies. *Frontiers in Pharmacology*. **14:** 1310023.

Zhu, X., Zhang, C., Liu, L., Xu, L. and Yao, L. (2024). Senolytic combination of dasatinib and quercetin protects against diabetic kidney disease by activating autophagy to alleviate podocyte dedifferentiation *via* the Notch pathway. *International Journal of Molecular Medicine*. **53(3):** 1-12.