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Antioxidant and Antidiabetic Properties of the Water Extract from Sigoise Olive Cultivar (*Olea europaea* L.), El Oued Region (Algeria)

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Abstract

Olive tree leaves (*Olea europaea* L.) have been widely used in Mediterranean traditional medicine to prevent and treat various ailments. This study investigated the effects of consuming a water extract of Sigoise olive leaves on antioxidant levels and type II diabetes. The extract was prepared by steeping 10 g of dried olive leaves in 500 mL of boiling water and then given to 20 Algerian volunteers (10 diabetic subjects and 10 healthy controls), who consumed it twice a day for a month. The volunteers were screened by biochemical blood tests before and by the end of the experiment. The antioxidant activity was assessed using DPPH (2,2-diphenyl-1-picryl-hydrazyl-based assay, 35.3 ± 0.5 mg/mL) and FRAP assays (ferric reducing antioxidant power assay, 8.3 ± 0.1 mg/mL). The quantitative analysis revealed high contents of total polyphenols (41.8 ± 0.8 mg gallic acid equivalent per 1 g of extract) and total flavonoids (14.3 ± 0.8 mg rutin equivalent per 1 g of extract). The hypoglycemic effect of the extract was shown, thus confirming that it helps improve renal function and prevents cardiovascular disorders in type II diabetic patients. No toxic effects on kidney or liver function were observed. Despite clear health-boosting benefits, further research is needed to fully validate them clinically.

Keywords: *Olea europaea*, Sigoise, polyphenols, flavonoids, antioxidant and antidiabetic properties

Introduction

Olea europaea L. (Oleaceae), commonly known as olive, is widely grown in the Mediterranean region. Algeria cultivates more than 166 olive varieties, including Chemlali, Azeradj, Sigoise, etc. [1]. The Sigoise variety was introduced in 1990 to boost the production of table olives in Western Algeria. Sigoise olives are characterized by high flesh/stone ratio (about 6.44), high sugar content (greater than 4 %), salt-water tolerance, resistance to cold and drought, as well as precocious flowering, easy harvesting performed almost entirely by hand picking, and being a good pollinator for the Chemlali variety [2, 3].

Olive leaves have a long history of medical use. They are rich in phenolic compounds, especially oleuropein (24.54 %), which is followed by hydroxytyrosol (1.46 %), luteolin-7-O-glucoside (1.38 %), verbascoside (1.11 %), apigenin-7-O-glucoside (1.37 %), and tyrosol (0.71 %). Luteolin, vanillic acid, and caffeic acid are present in trace amounts [4]. Recent studies have shown that the polyphenols in olive leaves exert many beneficial effects, such as antioxidant [5], anti-inflammatory, antimicrobial, hypoglycemic, antihypertensive, anticancer, anticholesterolemic [6], and antiviral. They also prevent and reduce the incidence of cardiovascular disorders.

Interestingly, the antioxidant properties of extracts from olive leaves vary greatly depending on the olive variety, genetic factors, and geographical conditions (Table 1).

Table 1.

Olive leaf antioxidant characteristics

Extraction type and extragent	Geographical origin	Variety	Antioxidant parameter	Results	Ref.
Ethanolic extraction	Lorestan (Iran)	Sevillano	DPPH	EC_{50} = 231.62 mg/mL	[7]
Maceration with hexane, ethyl acetate, and methanol	Sfax (Tunisia)	Chetoui	DPPH, FRAP, ORAC, β-carotene bleaching assay	The methanolic extracts obtained from stems, leaves, and seeds exhibited the highest antioxidant activities	[8]
Ethanolic extraction	Chlef (Algeria)	Sigoise	DPPH, FRAP and β-carotene bleaching assay	IC_{50} = 16.761 ± 1.58 – 147.802 ± 3.11 µg/mL	[9]
Maceration with ethanol, ethyl acetate, and hexane	Ain Defla (Algeria) Nabeul (Tunisia)	Chemlali, Octoubri, Gerboui, Rougette, Sayali, Sigoise, Sofiana, Verdal	DPPH ABTS	The ethanolic extract of the Sofiana variety represented the most active extract in the ABTS test with IC_{50} = 23.85 ± 0.58 mg/L. The ethanolic extract of the Verdal variety was the most potent inhibitor of DPPH with IC_{50} = 30.22 ± 1.34 mg/L.	[10]
Aqueous extraction	Alexandria (Egypt)	Picual, Tofahi, Shemlali	DPPH, FRAP and nitric oxide scavenging activity	IC_{50} = 55.82 ± 0.13 – 19.03 ± 0.13 µg/mL	[11]

DPPH – 2,2-diphenyl-1-picrylhydrazyl-based assay, FRAP – ferric reducing antioxidant power assay, ORAC – oxygen radical absorbance capacity assay, ABTS – 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) radical cation-based assay

Oxidative stress, an underlying trigger of diabetes mellitus and its complications, stems from overproduction of reactive oxygen species and intracellular oxidative damage. It can lead to alterations in mitochondrial morphology and function, inducing structural changes and functional abnormalities in macromolecules such as proteins, lipids and nucleic acids, ultimately resulting in apoptosis and accelerating the progression of diabetic complications [12]. Diabetes status is associated with hyperglycemia caused by insufficient insulin secretion, impaired insulin action, or both. According to the latest estimates, there are more than 150 million diabetics worldwide, and this number may double by 2025 [13, 14].

With over 35 million olive trees, Algeria [15] is well-positioned to address the widespread occurrence of diabetes mellitus by delving into the merits of olive tree leaves in treating this chronic metabolic disease.

This work aims to investigate, for the first time, the antioxidant activity and hypoglycemic effect of a fresh water extract from Sigoise olive leaves (El Oued region, Algeria) on human diabetic subjects.

1. Material and Methods

1.1. Chemicals and reagents. All chemicals (2,2-diphenyl-1-picrylhydrazyl (DPPH), $AlCl_3$, NH_4OH, ascorbic acid, Dragendorff reagent, EtOH, Folin–Ciocalteu reagent, gallic acid, HCl, $FeCl_3$, $MgCl_2$, MeOH, $K_3[Fe(CN)_6]$, quercetin, Na_2CO_3, NaCl, rutin, sodium dodecyl sulfate, NaOH, H_2SO_4, and trichloroacetic acid) were purchased from Sigma-Aldrich and used as received.

1.2. Plant material. The leaves of the Sigoise olive cultivar (*Olea europaea* L.), planted in the El Oued region (Algeria) in December 2022, were the subject of the study. To prepare the extract, 10 g of dry leaves were placed into 500 mL of boiling water and left to simmer for 10 min. The resulting extract was allowed to soak for an hour until it cooled down. Then, it was filtered and kept in the filtrate for later use.

1.3. Phytochemical tests. Following established protocols, a confirmatory qualitative phytochemical screening of the extract was conducted to determine the main classes of compounds (saponins, tannins, flavonoids, alkaloids, sterols, reducing sugars, free quinones, terpenoids, and anthraquinone) [16].

1.4. Quantification of total polyphenol contents (TPC). The TPC in the extract were assessed using the method described by Boizot & Charpentier [17], which employs the Folin-Ciocalteu reagent. With this aim, 200 µL of the extract, 1 mL of 10 of the 10-fold diluted Folin-Ciocalteu reagent, and 2 mL of water were mixed at room temperature for 4 min and incubated. Then, 0.8 mL of sodium bicarbonate (7.5 %) was added. The TPC was determined after 2 h of incubation at room temperature. The absorbance was measured at 765 nm with a SpectraMax PC 340 UV-VIS spectrophotometer (Molecular Bioproducts Corp., USA). The concentrations were expressed as milligrams of gallic acid equivalent per 1 g of extract (mg GAE/g).

1.5. Quantification of total flavonoid contents (TFC). The concentrations of total flavonoids in the extract (TFC) were measured using $AlCl_3$ and sodium hydroxide. 1 mL of the extract was added to 1 mL of $AlCl_3$ diluted in methanol (2 %). The mixture was shaken and incubated for 10 min at the laboratory temperature. The absorbance was measured at 430 nm with a spectrophotometer. The results were expressed as mg of rutin equivalent per 1 g of extract (mg RE/g) [18].

1.6. DPPH radical scavenging test. The antiradical activity of the extract against DPPH was assessed with some modifications to adapt the procedure. Briefly, the DPPH solution was prepared by dissolving 2.4 mg of DPPH in 100 mL of methanol. Then, 50 µL of the extract at various concentrations or standard ascorbic acid (vitamin C) were added to 1.95 mL of DPPH. The tubes were kept in the dark at room temperature for 30 min. The absorbance was read at 517 nm [19].

Scavenging activity was expressed as IC_{50} and the extract dose needed to induce 50 % inhibition. A lower IC_{50} value indicated a higher antioxidant activity of the extract.

1.7. Ferric reducing antioxidant power (FRAP) assay. A total of 0.5 mL of the extract was mixed with 1.25 mL of 1 % potassium ferrocyanide and 1.25 mL of phosphate buffer (0.2 M, pH 6.6). The mixture was incubated for 20 min at 50 °C in a water bath. After that, 1.25 mL of 10 % trichloroacetic acid was added, and the mixture was centrifuged for 10 min at 3000 rpm [20].

The absorbance was measured at 700 nm using a 1.25 mL aliquot of the supernatant, 0.25 mL of $FeCl_3$ (0.1 %), and 1.25 mL of distilled water. Ascorbic acid served as positive control.

1.8. Antidiabetic activity. The study was carried out at the Biochemistry Laboratory of El Oued University and the Public Health Institution in Guemar (Algeria). The participants were 20 adult volunteers (10 subjects with chronic diabetes and their 10 healthy relatives), all selected randomly. The two groups were matched for gender and age.

The criteria for inclusion were being aged 30–45 years and having type II diabetes. The participants were also required to undergo a series of medical tests before and after the experiment.

The criteria for exclusion were pregnancy or breastfeeding, insulin therapy, changes in medical treatment during the trials, diabetic complications, or poor metabolic control.

All subjects received a daily bottle containing the extract of boiled olive leaves, a glucometer for measuring their blood sugar, and an instruction card designed as a diabetes booklet. They were also instructed to drink two cups (2 × 250 mL; one in the morning on an empty stomach and the other in the evening, an hour before dinner) of the extract per day for a month and tasked with regularly measuring their blood glucose levels at home. Additionally, they were asked to undergo, before and after the trials, routine biochemical blood tests for blood glucose, urea, creatinine, total cholesterol, HDL cholesterol, LDL cholesterol, triglyceride, and calcemia [21].

Ethical permission for the study was granted by a certified medical specialist in diabetes treatment. Informed pre-study consent was obtained from all participants. The procedures were explained to them using simple language, and all collected data were kept confidential. The participants were free to withdraw from the study at any time.

1.9. Statistical Analysis. The experiments were carried out in three replications. The results were expressed as the mean ± standard deviation. One-way analysis of variance (ANOVA) followed by *P*-value adjustment for multiple comparisons were conducted using Tukey's *post-hoc* test. $P < 0.05$ was considered statistically significant. All data were processed using XLSTAT software (Lumivero, USA).

2. Results and Discussion

2.1. Phytochemical tests. Preliminary phytochemical screening revealed the presence of saponins, tannins, flavonoids, sterols, and quinones. However, the extract tested negative for alkaloids, glycosides, and terpenoids (Table 2).

2.2 Quantification of polyphenols, flavonoids, and antioxidant activity. The TPC and TFC values of the extract were determined (Table 3). The TPC assay indicated the TPC of 41.8±0.8 mg EAG/g extract, which is consistent with the results obtained by Ghasemi et al. [22], who reported the TPC ranging from 42.35 ± 0.002 mg GAE/g

to 190.65 ± 0.03 mg GAE/g for 17 cultivars of Iranian olive. Compare the above values with 1.6 mg GAE/g dry weight from [23].

Table 2.

Results of phytochemical tests of the Sigoise olive leaf extract ((+) presence; (–): absence)

Secondary metabolites	Results
Saponins	+
Tannins	+
Flavonoids	+
Alkaloids	-
Sterols	+
Glycosides	–
Quinones	+
Terpenoids	–
Anthraquinone	+

Table 3.

Total polyphenolic and flavonoid contents, DPPH radical and FRAP scavenging test of the Sigoise olive leaf extract

Sample	Total polyphenols (mg GAE/g)	Flavonoids (mg RE/g)	DPPH radical scavenging test, IC_{50} (mg/mL)	FRAP scavenging test, $A_{0.5}$ (mg/mL)
Olive leaf extract	41.8±0.8	14.3±0.8	35.3±0.5	8.3±0.1
Ascorbic acid	–	–	0.49±0.03	0.030±0.002

The flavonoid content (TFC) of the analyzed extract was estimated at 14.3±0.8 mg RE/g. This is comparable to the TFC (15.55 mg RE/g) found in another study of the aqueous methanol extract from olive leaves [24]. The differences in the concentrations of phenolic compounds can be attributed to the impact of biotic and abiotic factors, including the plant's maturity stage at harvest. The capacity of plants to produce secondary metabolites is also defined by their ontogenetic trajectories, with different metabolites being synthesized as a consequence of specific metabolic processes that are unique to each plant species. Numerous studies have demonstrated that the stage of vegetation growth affects the accumulation of specific classes of phenolic compounds [25]. Notably, a diet rich in phenolic compounds has generally been linked to many health benefits, including oxidative stress reduction, free radical scavenging, chelation of metal ions, and modulation of intracellular signaling pathways [26].

Ascorbic acid, used as a standard antioxidant for comparison, exhibited an extremely potent free radical scavenging activity (IC_{50} = 0.49 ± 0.03 mg/mL). In contrast, the antioxidant activity of the studied extract was 35.3 ± 0.5 mg/mL, i.e., it was less critical than that of ascorbic acid. Yet, this value was still higher than that in the aqueous extract of *O. europaea* leaves from [27], where the DPPH radical

scavenging activity was IC_{50} = 92.04 mg/mL. Compared to the methanolic extract of the Tunisian olive cultivar Chetoui (IC_{50} = 0.02 mg/mL) [9], the studied extract displayed lower antioxidant activity. Flavonoids and total phenols are two groups of bioactive substances that are likely responsible for the antioxidant activity observed. Tyrosol and hydroxytyrosol, the derivatives of oleuropein, have been shown to possess antiradical properties in both *in vitro* and *in vivo* studies [28]. Interestingly, there are some other phenolic compounds potentially contributing to the antioxidant activity of olive leaves. In [29], rutin, a compound identified in *O. europaea* leaves, decreased the oxidative stress-induced hepatotoxicity in rats fed a high-cholesterol diet. The data in [30] also suggest that luteolin may have protective effects against oxidative stress, thus slowing the development of cardiac dysfunction brought on by diabetes. The benefits of hydroxytyrosol and oleuropein due to antioxidant properties have been discovered *in vivo* [27, 31]. The strong antioxidant effect of olive leaves results from the synergy of phenolic components, including oleurosides (oleuropein and verbascoside), flavones (luteolin-7-glucose and diosmetin-7-glucose), flavonols (rutin), flavan-3-ols (catechin), and phenol substitutes (tyrosol, hydroxytyrosol, vanillin, vanillic acid, and caffeic acid) [32]. Therefore, the antioxidant activity depends on the extraction and drying methods, the cultivars used, and the chemical composition of the tested plants [33, 34].

Table 3 shows that the reduction potential of the studied extract was lower (8.3 ± 0.1 mg/mL) than that of standard ascorbic acid (0.03 ± 0.002 mg/mL), as indicated by the $A_{0.5}$ values. Although the extract had higher $A_{0.5}$, its reducing capacity was moderate. This discrepancy can be explained by variations in the concentrations of phenolic compounds. Antioxidants are commonly considered to function as reducers and inactivators of oxidants due to the presence of polyphenols and hydroxyl groups in phenolic compounds. Hence, the studied extract has a reduction potential and can act as an electron donor [35]. According to previous research, the reduction potential of a compound is a reliable indicator of its potential antioxidant activity [36].

2.3. Antidiabetic activity. To date, there is no known cure for diabetes. The primary focus has been on keeping blood sugar levels as close to normal as possible through a healthy diet, regular physical activity, maintaining a normal BMI, and taking diabetes medications. Olive leaves are widely used in complementary and alternative treatment of diabetes, but only a few human studies are available on the hypoglycemic effect of drinking boiled olive leaves.

Blood glucose levels, kidney function markers, “bad” and “good” cholesterol, and calcium levels were monitored in all subjects before the experiment (no extract consumed), over the trial days, and after the extract intake. After four weeks of consuming the extract, the participants experienced a reduction in their average blood sugar levels. Furthermore, there was a decrease in total cholesterol, “bad” cholesterol, creatinine, and urea, while “good” cholesterol and calcium levels increased. The results are summarized in Table 4.

All participants consumed the olive leaf extract twice a day for four weeks. By the end of the trial period, the blood glucose levels of the subjects with diabetes decreased significantly (from 1.96 to 1.12 g/L). The blood glucose levels of the healthy controls remained stable (1.096–0.862 g/L) throughout the experiment.

The hypoglycemic effect of *O. europaea* has been reported by several studies [37], in which the patients treated with the olive leaf extract had a significant decrease in

blood sugar levels compared to the untreated controls. Subsequent research on normal and diabetic rats has confirmed these findings [38–40]. Overall, from the results obtained, it is evident that olive leaves have a noticeable hypoglycemic effect on individuals with type II diabetes.

Table 4.

Effect of the Sigoise olive leaf extract on the biochemical parameters of healthy and diabetic participants before and after the extract intake

Parameter	Groups of participants			
	Diabetic patients before taking the extract	Diabetic patients after taking the extract	Healthy participants before taking the extract	Healthy participants after taking the extract
Glucose (g /L)	2.0±0.3[a]	1.1±0.3[b]	1.1±0.1[b]	0.86±0.07[b]
Urea (g/L)	0.3±0.1	0.21±0.04	0.25±0.09	0.21±0.08
Creatinine (g/L)	9±2	7±1	10±2	8±3
Total cholesterol (g/L)	2.1±0.3[a]	1.4±0.2[b]	2.5±0.4[a]	1.9±0.1[a]
HDL cholesterol (g/L)	0.5±0.2	0.64±0.04	0.5±0.3	0.6±0.1
LDL cholesterol (g/L)	1.3±0.2[a]	0.8±0.3[b]	1.6±0.2[a]	1.2±0.3[a]
Triglycerides (g/L)	1±1[a]	0.8±0.7[a]	1.4±0.5[a]	1.0±0.4[a]
Calcium contents (mg/L)	82±8	84±11	74±3	76±7

Means in the same raw followed by different letters are significantly different ($P \leq 0.05$)

Al-Azzawie and Alhamdani suggested treating diabetic patients with oleuropein, a potent antioxidant contained in olive leaves, to reduce oxidative stress and thus blood glucose. They found that the levels of blood glucose and most antioxidants in the treated participants were close to the control ones [41]. These results confirm the antihyperglycemic and antioxidant effects of oleuropein, indicating that crude oleuropein, responsible for the hypoglycemic activity of olive leaves, possesses both hypoglycemic and antidiabetic activities. The observed effects may be due to two possible mechanisms: increased insulin release and enhanced peripheral glucose uptake [42].

Another mechanism by which olive leaf extract exerts the hypoglycemic effect is through inhibiting the activity of pancreatic amylase. It has been revealed that oleuropein reduces blood glucose levels by inhibiting α-amylase activity *in vivo* [37].

Olive leaf extract is known to inhibit starch digestion and glucose uptake, as well as stimulate hepatic glycogen synthesis, resulting in reduced hyperglycemia. Starch digestion by intestinal enzymes and intestinal disaccharidase inhibition explain the hypoglycemic effect of olive leaf extract [43].

The studied extract also reduced the levels of serum urea and creatinine, the biomarkers of diabetes-related nephropathy, in the diabetic subjects. Elevated serum urea and creatinine, as important markers, are often associated with diabetic hyperglycemia. Many studies have claimed that consuming olive leaves decreases creatinine and urea levels in patients with diabetes. For example, in [18], the consumption of the olive leaf extract effectively lowered creatinine, urea, and uric acid levels in streptozotocin-induced diabetic male rats. In our study, the olive leaf extract had a positive effect on the lipid profile of both diabetic and healthy participants.

Type II diabetes raises the risk of cardiovascular disorders. Diabetic patients are two to four times more likely to develop cardiovascular complications compared with

healthy individuals. This is due to lipid and lipoprotein abnormalities that are common in type II diabetes, such as exceptionally high levels of total triglycerides, total cholesterol, low-density lipoprotein, and reduced levels of high-density lipoprotein [44].

The therapeutic utility of *O. europaea* as a powerful cholesterol-lowering agent has been widely recognized in traditional medicine [45]. The effectiveness of polyphenols in olive leaves, such as oleuropein, hydroxytyrosol, and rutin, in managing hypocholesterolemia caused by hyperglycemia has been highlighted, and oleuropein and hydroxytyrosol, both abundant in *O. europaea* leaves, are known for their cholesterol-lowering effects. Wang et al. confirmed that these compounds reduced serum levels of total cholesterol, triglycerides, and low-density lipoproteins in Wistar rats fed cholesterol-rich diets [30]. These results suggest that the phenolic components of olive leaves could represent a new valuable cholesterol-lowering source for developing new cholesterol-lowering medications and treatments for various heart diseases related to type II diabetes.

Levy et al. claimed that total serum calcium levels are higher in patients with diabetes than in healthy people [46]. Thus, calcium may be involved in developing and maintaining type II diabetes. Kim et al. observed an increased risk of diabetes in middle-aged and elderly Koreans with elevated serum calcium levels [47]. Over recent decades, the resistance and secretion of insulin has been proved to depend on calcium homeostasis, which means that insulin secretion in response to an increase in plasma glucose concentration is a Ca^{2+} dependent process. Alterations in insulin secretion have also been implicated in disorders of blood glucose homeostasis [48], and elevated cytosolic calcium has been associated with increased expression of GLUT4 transporters in the myocyte. It enhances the insulin-stimulated glucose transport activity in these cells [49]. Since defects in insulin secretion and action are linked to type II diabetes, abnormal calcium homeostasis is expected to play an essential role in developing type II diabetes [50].

The hypoglycemic effect of olive leaves found in this study needs to be further examined in order to identify the ideal dose, duration, preparation methods, and timing of consumption for maximizing their impact on blood glucose.

Conclusions

The water extract from Sigoise olive leaves, rich in phenolic compounds and characterized by high antioxidant activity, offers clear benefits for preventing and treating diabetes. By the end of the experiment, all subjects with diabetes demonstrated a significant decrease in their blood sugar, total cholesterol, "bad" cholesterol, creatinine, and urea levels, while the levels of calcium and "good" cholesterol increased. The hypoglycemic capacity of the extract appears to be linked to the antioxidative action of olive leaves. However, further research is needed in order to uncover and fully understand the molecular mechanisms behind the active constituents of olive leaves.

Institutional Review Board Statement. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Faculty of Natural and Life Sciences, University of El Oued (protocol code 001 dated December 2023).

Informed Consent Statement. Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest. The authors declare no conflicts of interest.

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ОРИГИНАЛЬНАЯ СТАТЬЯ

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Антиоксидантные и антидиабетические свойства водного экстракта листьев оливы сорта Sigoise (*Olea europaea* L.), регион Эль-Уэд (Алжир)

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Аннотация

Листья оливы (*Olea europaea* L.) широко используются в традиционной медицине Средиземноморья для профилактики и лечения различных заболеваний. В статье рассматриваются антиоксидантные и антидиабетические свойства водного экстракта листьев оливы сорта Sigoise (Алжир). Экстракцию проводили путем настаивания 10 г сухих листьев в 500 мл кипящей воды. Исследование выполнено при участии 20 добровольцев (10 пациентов с диабетом II типа и 10 здоровых лиц контрольной группы), которые принимали экстракт дважды в день в течение месяца. Биохимические показатели крови фиксировали до и после эксперимента. Антиоксидантную активность оценивали по результатам DPPH-теста (в реакции с 2,2-дифенил-1-пикрилгидразилом, 35.3 ± 0.5 мг/мл), а также FRAP-теста (по железо-восстанавливающей способности, 8.3 ± 0.1 мг/мл). Количественный анализ полученного экстракта показал высокое содержание полифенолов (41.8 ± 0.8 мг галловой кислоты/г экстракта) и флавоноидов (14.3 ± 0.8 мг рутина/г экстракта). Установлено, что экстракт листьев оливы оказывает выраженный гипогликемический эффект, тем самым нормализуя функцию почек и снижая риск сердечно-сосудистых заболеваний у пациентов с диабетом II типа. Токсического поражения почек и печени не обнаружено. Однако, несмотря на общую положительную динамику у пациентов с диабетом, терапевтический потенциал водного экстракта листьев оливы должен быть подтвержден в дальнейших клинических исследованиях.

Ключевые слова: *Olea europaea*, Sigoise, полифенолы, флавоноиды, антиоксидантные и антидиабетические свойства.

Заключение Комитета по этике. Исследование проведено в соответствии с положениями Хельсинкской декларации Всемирной медицинской ассоциации и одобрено этическим комитетом факультета естественных и биологических наук Университета Эль-Уэд (протокол № 001, декабрь 2023 г.).

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