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# Effects of pan-fried *Ficus carica* seed oil and sunflower oil on oxidative stress, inflammation, and tissue damage in rats

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## ABSTRACT

**Aim:** To compare the effects of long-term, regular pan-frying with sunflower oil and *Ficus carica* seed oil on liver and kidney damage in an experimental model.

**Method:** For the experiment, 18 Wistar Albino rats were divided into 3 groups (n=6). The oils were pan fried for 15 minutes. The experimental animals in the Sunflower Oil group were given 3 ml/kg of pan-fried sunflower oil by orogastric gavage for 30 days, and the experimental animals in the *Ficus carica* Seed Oil group were given 3 ml/kg of pan-fried *Ficus carica* seed oil by orogastric gavage for 30 days. The rats in the control group were not given fried oil. At the end of the experiment, blood, liver and kidney tissues were taken from the sacrificed rats and biochemical and histopathological evaluations were performed.

**Results:** The oxidative damage and proinflammatory parameters of sunflower oil were significantly higher than the control group. Liver and kidney damages were also higher than *Ficus carica* seed oil. In both pan fried oil groups, antioxidant levels decreased compared to the control group. In histopathological results, liver degeneration, portal inflammation, focal necrosis and apoptosis, peritoneal necrosis, sinusidal dilatation and centrilobular necrosis were found to be at lower levels in those applied with *Ficus carica* compared to the sunflower oil group.

**Conclusions:** It was determined that *Ficus carica* seed oil caused less damage to the liver and kidney compared to pan-fried sunflower oil. It is recommended to prefer *Ficus carica* seed oil in pan fried foods.

**Keyword:** *Ficus carica* seed oil, sunflower oil, oxidative stress, pan frying, tissue damage, inflammation.

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## 1. Introduction

Frying is an essential process for consuming foods and is carried out in the form of deep and pan frying. When pan frying, there is a thin layer of oil and the frying temperature is around 150-200°C [1]. Pan frying is the main frying method used in daily routine and home life, and people are exposed to the effects of pan frying every day [2]. During the frying process, chemical reactions occur in the oil exposed to high temperatures and functional losses occur in the oil [3]. Components such as essential unsaturated polyunsaturated fatty acids (PUFA), especially vitamins A, D, E and K, may be partially lost at high temperatures. In the pan frying process, unwanted chemical compounds are formed due to the large surface

and volume ratio [4]. As a result of frying oils, hydrolysis reactions occur. As a result, free fatty acids increase and radical oxygen species (ROS) are formed. This causes liver and kidney damage [5-7].

According to a study conducted in 2022, Turkey ranks first in the world in *Ficus carica* production and export, accounting for 23.30% of the world's *Ficus carica* production, 43.09% of its exports in value and 48.43% in quantity [8]. *Ficus carica* seed oil was found to contain 53.1% linolenic acid, 21.1% linoleic acid, 13.8% palmitic acid and 9.8% oleic acid [9]. It was found that unsaturated fatty acids constitute a high proportion of total fatty acids. In sunflower oil, 7.9-12.0% palmitic acid, 34.4-45.5% oleic acid and 36.9-47.9% were found [10]. *Ficus carica* seed oil contains high levels of essential fatty acids. Linoleic acid, one of the essential fatty acids, is also important in the formation of the immune response [10]. *Ficus carica* seed oil contains high levels of Omega-3 and vitamin E, and 391 mg of gamma tocopherol was detected in 100 grams of oil [11]. Thanks to these constituents, the antioxidant property of *Ficus carica* seed oil has been demonstrated in a recently conducted study on renal ischemia [12].

Sunflower oil contains substances such as hydrocarbons, sterols and waxes, as well as antioxidants such as alkaloids, flavonoids and terpenoids [13]. Sunflower oil is obtained from the seeds of the *Helianthus annusuus* plant. Sunflower oil contains 15% saturated fatty acids and the remaining part contains unsaturated fatty acids [14]. Sunflower cultivation and oil production is very common not only in Turkey but also worldwide and is a leader in vegetable oil production. Sunflower oil production is at 20.36 million tons in 2023, corresponding to 9.36% of the world's total vegetable oil production, and ranks 4th after palm oil, soybean and rapeseed [15]. In our country, sunflower oil production constitutes 69% of vegetable oil production, meets approximately 84% of total liquid oil consumption and 32% of total oil use alone. It ranks first in both production and consumption of vegetable oils in Turkey [16].

Oxygen radicals are formed in all oils fried with the pan-frying effect and there is a risk of damage to various organs. The liver functions in glycogen storage, blood storage and filtering, bile production, cholesterol synthesis and storage, removal of many toxic substances from the body, and balancing triglyceride content [17]. The kidneys balance the body's water, electrolytes, and acid-base to create a stable environment for tissue and cell metabolism. A kidney disorder disrupts renal autoregulation and blood flow [18].

Oxidative stress can lead to functional impairments in various organs and tissues by disrupting cellular homeostasis and causing oxidative damage to biomolecules such as lipids, proteins, and DNA. The liver and kidneys are among the organs susceptible to oxidative stress due to their metabolic activities, extensive blood supply, and exposure to the formation of reactive oxygen species. Indeed, numerous studies conducted in recent years have demonstrated that the liver and kidneys serve as suitable experimental models for investigating oxidative stress-induced damage [19,20].

The aim of this study was to compare the effects of long-term, regular pan-frying with sunflower oil and *Ficus carica* seed oil on liver and kidney damage in an experimental model.

## 2. Materials and methods

***2.1. Ethical Statement:*** Our study was approved by the Adnan Menderes University Animal Experiments Local Ethics Committee

(ADÜ-HADYEK) with the decision numbered 64583101/2023/09 and dated 19/01/2023.

***2.2. Experimental Design:*** The study was conducted with 18 male Wistar albino rats weighing between 250-400 g. Rats were obtained from the Animal Research Center of Adnan Menderes University and maintained under conditions of 40–60% relative humidity, an ambient temperature of 22 ± 1°C, and a 12/12-h light/dark cycle. Standard pellet feed was used to feed the rats. Tap water was used as water. Feed and water were provided *ad libitum*. The rats were divided into 3 groups, and the study was started after they adapted to the environment. A 30-day period was selected for the study. The reason for this choice is that, as noted in previous studies involving experimental animals, effects lasting 28 days or longer are classified as chronic or long-term effects [21-23].

**Group 1:** Group SO (sunflower oil group); 3 ml/kg pan fried sunflower oil (ONEVA; Istanbul, Turkey) was given by orogastric gavage for 30 days.

**Group 2:** Group FCSO (*Ficus carica* seed oil group); 3 ml/kg pan fried *Ficus carica* seed oil oil (ONEVA; Istanbul, Turkey) was given by orogastric gavage for 30 days.

**Group 3:** Control Group; 3 ml/kg tap water was given by orogastric gavage for 30 days.

The oils were heated in a 28-cm frying pan, 50 mL at a time, at 180°C for 15 minutes. The oils were then stored in airtight bottles, and air was displaced with nitrogen before administration to the rats. No food matrix was included during the heating procedure; therefore, the experiment was designed to standardize thermal exposure to the oils rather than to reproduce household frying of a specific food.

After 24 hours following the 30th orogastric gavage application, all experimental animals were anesthetized with ketamine (75 mg/kg) and xylazine (10 mg/kg) and sacrificed after cervical dislocation. While the rats were anesthetized, the anterior abdominal wall was opened by incision and 2 ml of blood was taken from the heart by intracardiac route. Blood was centrifuged and serums were prepared for analyses. Liver and kidney tissues were taken. Liver and kidney tissue samples were stored at -80ºC for biochemical analyses and in 10% formaldehyde solution at room temperature for histological examination.

***2.3. Biochemical and Histopathological Analyses:*** AST and ALT levels were measured in serum, and GPx, MDA, CAT, IL-1b and TNF-a levels were measured in prepared tissue homogenates. Biochemical analyses were performed with purchased commercial kits (BioVision, USA).

For histopathological analyses; degeneration, portal inflammation, focal (focal lytic) necrosis and apoptosis, periportal necrosis examination, sinusoidal dilatation and centrilobular necrosis in the liver; tubular dilatation, Bowman capsule dilatation, myoglobin cast formation, tubular necrosis, interstitial inflammatory infiltration examination in the kidney were performed. Histopathological analyses were scored between 1-5 [33,34], [36]. Tissues were fixed in paraffin after the standard follow-up procedure, and serial sections of 2-3 µm thickness were obtained from the obtained paraffin blocks using a microtome (Thermo Shandon HM 430 Sliding Microtome, Thermo Fisher Scientific Inc., MA, USA). These sections were placed on slides for light microscopic examination. The slides, which were kept in a 37°C oven overnight, were stained with Hematoxylin-Eosin using an automatic staining device (Sakura Tissue-Tek, 49310521-1007, USA) for histopathological evaluation.

***2.4. Statistical Analyses:*** Results are shown as means ± standard deviation (SD). Statistical analyses were performed using GraphPad Prism 9 (GraphPad Software Inc., San Diego, CA, USA). Data were subjected to ANOVA using Tukey's multiple analysis method to determine differences between values, and immunohistochemical results were subjected to Dunn's multiple comparisons test. In nonparametric analyses (evaluation of histopathological scores), the Kruskal Wallis method was used. *p* value of less than 0.05 was considered statistically significant.

## 3. Results

***3.1. Serum AST and ALT Levels:*** Serum AST levels were significantly increased in the sunflower oil group compared with the control group ($p<0.05$), whereas an increase was also observed in the Ficus carica seed oil group. These findings indicate that exposure to pan-fried oils was associated with hepatic injury, with the more pronounced alteration observed in the sunflower oil group (Table 1).

Serum ALT levels were significantly increased in the sunflower oil group compared with the control group ($p<0.05$), whereas ALT also showed an increase in the Ficus carica seed oil group. Overall, the biochemical findings were consistent with greater hepatic injury in the sunflower oil group than in the Ficus carica seed oil group (Table 1).

***3.2. Kidney GPx, CAT, MDA, TNF-a and IL-1b Levels:*** Kidney GPx levels significantly decreased in the sunflower oil group compared with the control group ($p<0.05$), indicating impaired antioxidant defense. GPx levels also decreased in the Ficus carica seed oil group, although the magnitude of change was lower (Table 2).

Kidney CAT levels were significantly decreased in the sunflower oil group compared with the control group ($p<0.001$), indicating a marked reduction in antioxidant capacity (Table 2).

Kidney MDA levels were significantly increased in the sunflower oil group compared with the control group ($p<0.001$). MDA was

**Table 1.** Serum AST and ALT levels of the groups.

| Variables | Control | SO | FCSO |
|---|---|---|---|
| **AST (U/L)** | 82.33±12.60 | 110.0±21.21* | 102.7±16.73 |
| **ALT (U/L)** | 35.83±5.31 | 49.00±7.32** | 40.17±3.87$^{\dagger}$ |

*SO: Sunflower oil group; FCSO: Ficus carica seed oil group; AST: Aspartate aminotransferase; ALT: Alanine aminotransferase; *Control vs SO, P:0.0411; **Control vs SO, p:0.0034; SO vs FCSO, p: 0.0330.*

**Table 2.** Renal tissue GPx, CAT, MDA, TNF-α, and IL-1β levels of the groups.

| Variables | Control | SO | FCSO |
|---|---|---|---|
| **GPx (mU/mL)** | 852.2±65.32 | 655.5±74.96** | 677.8±89.19* |
| **CAT (mU/mL)** | 434.0±58.45 | 310.0±43.55*** | 382.2±26.62$^{+}$ |
| **MDA (nmol/g tissue)** | 270.2±45.67 | 403.5±73.37** | 371.0±36.87* |
| **TNF-a (pg/g tissue)** | 478.3±52.21 | 588.7±81.67* | 551.8±73.77 |
| **IL-1b (pg/g tissue)** | 462.7±55.09 | 593.8±89.82* | 469.8±67.21$^{\dagger}$ |

*SO: Sunflower oil group; FCSO: Ficus carica seed oil group; GPx: Glutathione peroxidase; CAT: Catalase; MDA: Malondialdehyde; TNF-α: Tumor necrosis factor-alpha; IL-1β: interleukin-1 beta; *Control vs Experimental Groups, p<0.05; **Control vs Experimental Groups, p<0.005; ***Control vs Experimental Groups, p<0.001; $^{\dagger}$SO vs FCSO, p<0.05*

also significantly increased in the Ficus carica seed oil group compared with the control group ($p$<0.05), indicating that both heated oils were associated with lipid peroxidation, with a more pronounced effect in the sunflower oil group (Table 2). Kidney TNF-α levels increased in both oil-treated groups compared with the control group; the increase was statistically significant in the sunflower oil group ($p$<0.05) (Table 2). Kidney IL-1β levels increased in both oil-treated groups compared with the control group. Importantly, IL-1β levels were significantly lower in the FCSO group than in the SO group (Table 2).

***3.3. Liver GPx, CAT, MDA, TNF-a and IL-1b Levels:*** Liver GPx levels were significantly decreased in the sunflower oil group compared with the control group ($p$<0.05). GPx levels also decreased in the Ficus carica seed oil group (Table 3).

Liver CAT levels were significantly decreased in the sunflower oil group compared with the control group ($p$<0.001). A decrease was also observed in the Ficus carica seed oil group; the corresponding statistical result is presented in Table 3.

Liver MDA levels were significantly increased in the sunflower oil group compared with the control group ($p$<0.001), and a significant increase was also observed in the Ficus carica seed oil group ($p$<0.05) (Table 3).

Liver TNF-α levels were significantly increased in both the sunflower oil and Ficus carica seed oil groups compared with the control group ($p$<0.05) (Table 3).

Liver IL-1β levels increased in both oil-treated groups compared with the control group; however, the increase in the FCSO group was not statistically significant compared with the control group ($p$>0.05) (Table 3).

For histopathological evaluations, Bowman Capsule Dilatation, Tubular Epithelial Degeneration, Necrosis of Tubular Epithelium, Tubular Dilatation and Interstitial Inflammatory Infiltration analyses were performed on the kidney tissue. In all analyses, the kidney tissues of rats given sunflower oil were statistically significantly damaged ($p$<0.05) compared to the rats in the control group, while the damage in the group given *Ficus carica* seed oil was not significant (Table 4, Figure 1).

Degeneration, Portal Inflammation, Focal Necrosis and Apoptosis, Periportal Necrosis, Sinusoidal Dilatation and Centrilobular Necrosis analyses were performed on the liver tissue. In all analyses, kidney tissues of rats given sunflower oil were damaged statistically significantly ($p$<0.05) compared to rats in the control group, while damage in the *Ficus carica* seed oil group was lower than in the sunflower group for all parameters (Table 5, Figure 2).

**Table 3:** Liver tissue GPx, CAT, MDA, TNF-a and IL-1b levels of the groups.

| Variables | Control | SO | FCSO |
|---|---|---|---|
| **GPx (mU/mL)** | 709.0±89.72 | 475.8±82.26*** | 557.3±81.02* |
| **CAT (mU/mL)** | 520.8±80.61 | 294.2±75.88*** | 400.3±61.06* |
| **MDA (nmol/g tissue)** | 231.5±48.08 | 414.2±60.22*** | 329.7±58.27*† |
| **TNF-a (pg/g tissue)** | 696.2±91.06 | 845.3±53.66* | 830.3±104.2* |
| **IL-1b (pg/g tissue)** | 231.5±48.08 | 414.2±60.22* | 329.7±58.27 |

*SO: Sunflower oil group; FCSO: Ficus carica seed oil group; GPx: Glutathione peroxidase; CAT: Catalase; MDA: Malondialdehyde; TNF-α: Tumor necrosis factor-alpha; IL-1β: interleukin-1 beta; *Control vs Experimental Groups, p<0.05; **Control vs Experimental Groups, p<0.005; ***Control vs Experimental Groups, p<0.001; †SO vs FCSO, p<0.05.*

**Table 4.** Histopathological analyses of kidney tissue of the groups.

| Scores | Control | SO | FCSO |
|---|---|---|---|
| **Bowman capsule dilatation** | 0.33±0.52 | 2.60±0.55** | 2.00±0.71 |
| **Tubular epithelial degeneration** | 0.33±0.52 | 2.40±0.55** | 1.80±0.45 |
| **Necrosis of tubular epithelium** | 0.00±0.00 | 1.40±0.55** | 0.80±0.45 |
| **Tubular dilatation** | 0.00±0.00 | 2.60±0.55** | 1.80±0.84 |
| **Interstitial inflammatory infiltration** | 0.00±0.00 | 2.60±0.55*** | 1.60±0.55 |

*SO: Sunflower oil group; FCSO: Ficus carica seed oil group; **Control vs Experimental Groups, P<0.005; ***Control vs Experimental Groups, P<0.001*

**Table 5:** Histopathological analyses of liver tissue of the groups.

| Scores | Control | SO | FCSO |
|---|---|---|---|
| **Degeneration** | 0.00±0.00 | 1.00±0.89* | 0.40±0.55 |
| **Portal inflammation** | 0.00±0.00 | 1.00±0.89* | 0.40±0.55 |
| **Focal necrosis and apoptosis** | 0.00±0.00 | 2.00±0.89** | 1.40±0.55* |
| **Periportal necrosis** | 0.00±0.00 | 1.00±0.89* | 0.50±0.55 |
| **Sinusoidal dilatation** | 0.00±0.00 | 2.00±0.89** | 1.40±0.55* |
| **Centrilobular necrosis** | 0.00±0.00 | 1.40±0.55** | 0.40±0.55 |

*SO: Sunflower oil group; FCSO: Ficus carica seed oil group; *Control vs Experimental Groups, p<0.05; **Control vs Experimental Groups, p<0.005.*

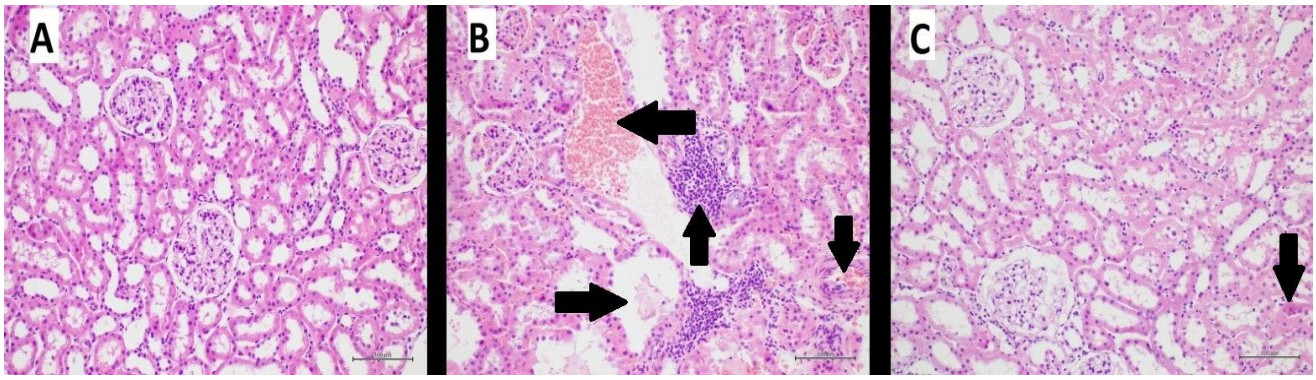


**Figure 1.** Images of kidney tissues after staining with Hematoxylin-Eosin dye (x200). A. Control group, B. SO group, C. FCSO group. Histopathological changes are indicated with black arrows.

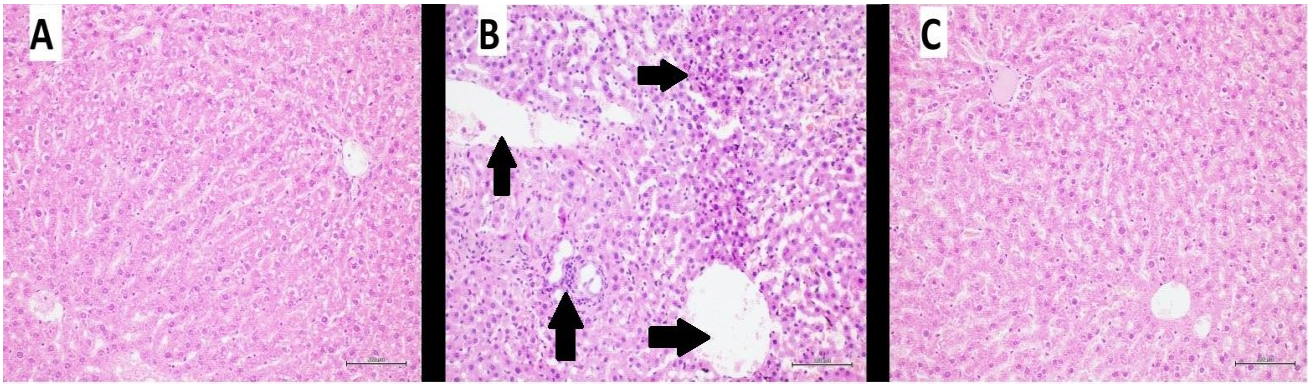


**Figure 2.** Images of liver tissues after staining with Hematoxylin-Eosin dye (x200). A. Control group, B. SO group, C. FCSO group. Histopathological changes are indicated with black arrows.

## 4. Discussion

The present study investigated the effects of pan-fried sunflower oil and Ficus carica seed oil on both liver and kidney tissues because these organs are particularly vulnerable to dietary lipid-derived oxidative stress and play central roles in metabolism, detoxification, and elimination of potentially harmful compounds. Evaluating both organs therefore provides a broader assessment of the systemic biological consequences of exposure to thermally oxidized oils. While previous studies have reported the adverse effects of repeatedly heated or fried oils and the protective properties of Ficus carica seed oil in different experimental models, comparative data regarding the biological effects of these two oils after pan-frying are limited. Thus, the present study provides a comparative evaluation of oxidative stress, inflammation, and histopathological alterations in both liver and kidney tissues, offering a broader experimental perspective than studies focusing on a single oil or organ.

During pan frying, oils are exposed to more oxygen and are subject to oxidative damage. The chemical changes that occur depend on the amount of oil, the surface area, and the duration of frying [1], [24]. In the study conducted by Andrikopoulos et al. (2002), margarine and olive oil were fried by deep frying and pan frying methods, and as a result of the study, it was determined that the deterioration in the oil content during the pan frying process was greater than that of the deep frying process [25]. In the study conducted by Şirinyildiz and Yorulmaz (2024), a significant increase was found in the levels of 3-MCPD, a potentially harmful heat-induced food contaminant, was measured to assess the formation of toxic processing-related compounds in the oils, which has been shown to have a toxic effect on kidney and liver tissues, at the end of the frying process in sunflower, hazelnut, corn and olive oils using the pan frying method [26]. In our study, because of pan frying of both sunflower oil and *Ficus carica* seed oil, damage was detected in kidney and liver tissues compared to the tissues of rats that were not exposed to fried oil. On the other hand, it was determined that the damage caused by frying *Ficus carica* seed oil was significantly lower than sunflower oil in terms of biochemical and histopathological aspects.

It has been found that fried oils cause a decrease in renal plasma flow and glomerular filtration rate [6]. It has also been observed that there is damage to the glomeruli due to an increase in systolic and diastolic blood pressure [27]. It has been observed that non-alcoholic fatty liver disease develops in people who are fed pan fried oil for a long time [28]. Irreversible pathological changes occur in kidney function due to the decrease in the glomerular filtration rate in the kidney. It has been stated that the degree of kidney diseases gradually increases due to the decrease in the glomerular filtration rate [29,30]. In our study, sunflower oil and *Ficus carica* seed oil, which we gave by orogastric gavage method as 3 ml/kg, were given to the groups for 30 days. The histopathological result of our study revealed dilatation in the Bowman capsule, tubular epithelial degeneration, necrosis in the tubular epithelium, and tubular dilatation in the kidney tissue with the consumption of pan-fried oils.

There are studies showing that frying oils cause damage to liver tissue and that this damage leads to hepatocyte death and chronic liver disease [7], [31]. In acute or chronic cases, hepatocyte damage and inflammation occur. Damage to the liver causes liver necrosis. In the

fibrotic process, regenerated hepatocytes are formed and nodules occur. Oxidative stress and inflammation play a role in the pathogenesis of hepatic diseases [32]. It has been shown that liver problems can be prevented by reducing oxidative damage [33]. Increased MDA levels indicate enhanced lipid peroxidation and oxidative damage, whereas decreased GPx and CAT activities reflect impaired antioxidant defense under excessive oxidative stress. Elevated TNF-α and IL-1β levels indicate the activation of inflammatory pathways in response to oxidative stress and tissue injury. Our study found that histopathological pan-fried sunflower oil caused significantly more degeneration in liver cells compared to pan-fried *Ficus carica* seed oil, and necrosis in the tubular epithelium was detected at a higher rate in the sunflower oil group. The biochemical and histopathological findings collectively indicate that increased oxidative stress and inflammation may contribute to cellular injury and structural damage in both the liver and kidneys.

Previous studies have shown that Ficus carica seed oil has a protective effect against kidney damage. In the study conducted by İşler et al. (2022), it was observed that the effects of acute myoglobinuric kidney injury were significantly improved with the application of *Ficus carica* seed oil [34]. In the study conducted by Şirinyıldız and Öğüt (2023), it was observed that *Ficus carica* seed oil reduced the negative effects of renal ischemia-reperfusion injury [35]. In the study conducted by Orak et al. (2021), it was seen that the application of *Ficus carica* seed oil had positive effects against mesenteric ischemia-reperfusion injury in the digestive tract [36]. In our study, biochemical and histopathological results in both kidney and liver tissues showed that *Ficus carica* seed oil had significantly positive effects on health compared to sunflower oil, which is the most used oil type in our country.

The present findings may be relevant to metabolic conditions in which oxidative stress and chronic inflammation contribute to disease development and progression, including type 2 diabetes, prediabetes, metabolic syndrome, fatty liver disease, and obesity [37-41]. The novelty of the present study is the experimental comparison of the biological consequences of exposure to pan-fried Ficus carica seed oil and sunflower oil, demonstrating comparatively lower oxidative, inflammatory, and histopathological alterations in animals exposed to Ficus carica seed oil under the conditions tested. These results do not establish a direct clinical benefit or support the therapeutic use of Ficus carica seed oil in humans. Nevertheless, they provide preliminary translational evidence that the choice of dietary oil used during thermal processing may influence the biological consequences of exposure to fried lipids and may be relevant to the overall oxidative burden associated with fried food consumption. This observation may be particularly relevant for populations at risk of metabolic disorders characterized by increased oxidative stress and inflammation. Well-designed human studies are required to determine whether these experimental findings translate into clinically meaningful effects on metabolic health. Glutathione peroxidase (GPx) and catalase (CAT) are major endogenous antioxidant enzymes that constitute an important component of the cellular defense system against reactive oxygen species (ROS), whereas malondialdehyde (MDA) is a widely recognized marker of lipid peroxidation and oxidative damage. Under conditions of oxidative stress, increased ROS production is generally associated with elevated MDA levels

and a reduction in antioxidant defense capacity, reflected by decreased GPx and CAT activities. In addition, interleukin-1β (IL-1β) and tumor necrosis factor-α (TNF-α) are pro-inflammatory cytokines that are frequently elevated during oxidative and inflammatory injury, contributing to the amplification of tissue damage through the reciprocal interaction between oxidative stress and inflammation [33-41]. The measurement results included in our study are supported by scientific literature.

***4.1. Limitations:***

Several limitations should be considered when interpreting these findings. First, the relatively small sample size (n=6 per group) may have limited statistical power and the generalizability of the results. Second, the oils used in this experiment were not comprehensively characterized before or after heating with respect to their fatty acid profiles, antioxidant content, oxidative stability, or specific oxidation products such as aldehydes, trans fatty acids, or other lipid-derived compounds. Accordingly, the mechanisms responsible for the observed tissue injury cannot be attributed to specific chemical changes in the oils and should be interpreted indirectly. Third, orogastric gavage was selected to standardize dose and exposure, but this route does not fully reproduce typical human dietary intake, in which fried oils are consumed within a complex food matrix and together with other nutrients. Fourth, the present protocol evaluated a single exposure duration and endpoint (30 days); therefore, it does not distinguish early from progressive injury or provide information regarding recovery after discontinuation of exposure. Future studies should include larger sample sizes, longitudinal and recovery assessments, direct physicochemical characterization of oils before and after heating, and analyses of specific oxidation products.

***4.1. Conclusions:*** In conclusion, in this study, the oxidative damage caused by pan-fried sunflower oil and *Ficus carica* seed oil in rats was investigated. In our study, damage was detected in the kidney and liver, and an increase in liver and kidney damage markers was also detected. Our study is the first study to investigate the effects of pan-fried *Ficus carica* seed oil and sunflower oil. As a result; according to the findings obtained with *Ficus carica* seed oil and sunflower oil, the antioxidant capacities of these oils are high. Even when *Ficus carica* seed oil is used for frying, its antioxidant rate does not decrease significantly, and it gives more positive results compared to frequently consumed sunflower oil. As a result, *Ficus carica* seed oil can be preferred as a frying oil.

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***Conflict of Interest:*** *The authors declared no conflict of interest.*

***Ethical Statement:*** *The study was approved by the Adnan Menderes University Animal Experiments Local Ethics Committee (ADÜ-HADYEK) with the decision numbered 64583101/2023/09 and dated 19/01/2023.*

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