The Effects of *Cynara scolymus* L. Leaf and *Cichorium intybus* L. Root Extracts on Carbon Tetrachloride Induced Liver Toxicity in Rats

Fallah Huseini H (Ph.D.)[1*], Zareei Mahmoudabady A (Ph.D.)[2], Ziai SA (Ph.D.)[3], Mehrazma M (Ph.D.)[4], Alavian SM (Ph.D.)[5], Mehdizadeh M (Ph.D.)[6], Radjabian T (Ph.D.)[7]

1- Department of Pharmacology and Applied Medicine, Institute of Medicinal Plants, ACECR, Karaj, Iran
2- Department of Biochemistry, Baqyiatallah University of Medical Sciences, Tehran, Iran
3- Department of Pharmacology, Faculty of Medicine, Shahid Beheshti University, Tehran, Iran
4- Department of Pathology Iran University of Medical Sciences, Tehran, Iran
5- Research Center for Gastroenterology and Liver Diseases, Baqiyatallah University of Medical Sciences, Tehran, Iran
6- Department of Anatomical Sciences, Cellular and Molecular Research Center, Iran University of Medical Sciences Tehran, Iran
7- Department of Biology, Faculty of Science, Shahed University, Tehran, Iran
[*]Corresponding author: Department of Pharmacology, Institute of Medicinal Plants, ACECR, Karaj - Gazvin Freeway, Supa Boulevard, Jahade- Daneshgahi Research Society, Karaj, Islamic Republic of Iran.
Tel: +98 – 261 - 4764010, Fax: +98 – 261 - 4764021
E-mail: huseini_fallah@yahoo.com

Receive: 13 Nov. 2010 **Acceptance:** 19 Jan. 2011

Abstract

Background: ***Cynara scolymus*** **and** ***Cichorium intybus*** **are popular herbal remedy in folk medicine for liver disorders. Although many experimental studies carried out, scientifically reliable data needed to verify minimum effective dosage and efficacy of these medicinal plants.**

Objective: In present investigation, the effects of *C. scolymus* leaf and *C. intybus* root extracts at different doses were tested against CCl_4 induced rats liver toxicity.

Methods: The *C. scolymus* leaf and *C. intybus* root extracts at the doses of 300, 600 and 900 and 150, 300 and 450 mg/kg/day were prepared respectively. Liver intoxication was induced in 7 groups of rats by intraperitoneal injection of 1 ml/kg of 1:1 CCl_4 in olive oil for two successive days. One group kept as control and six different doses of plant extracts were administered to six groups simultaneously with CCl_4 administration. The serum levels of ALT, AST and ALP, liver tissue glutathione and catalase activity as well as liver tissue microvesicular steatosis (MVS) and pericentral coagulation necrosis (PCN) were determined after three days.

Results: The serum ALT, AST and ALP and liver tissue MVS were significantly reduced in both the *C. scolymus* and *C. intybus* groups at the doses of 900 and 450 mg/kg/day respectively while liver tissue PCN significantly reduced in *C. scolymus* 900 mg/kg/day group only as compared to control group.

Conclusion: In present study administration of the *C. scolymus* leaf (900 mg/kg/day) and *C. intybus* root (450 mg/kg/day) extracts ameliorated CCl_4 induced rat serum liver enzyme changes and liver tissue histopathological damage.

Keywords: ***Cynara scolymus, Cichorium intybus,*** **Medicinal plants, Liver toxicity**

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]

Introduction

In Iranian traditional system of medicine *Cynara scolymus* L. and *Cichorium intybus* L. are used for treatment of several diseases including hepatic disorders [1 - 4]. The leaf extract of *C. scolymus* has shown to be effective in lowering blood cholesterol levels, improving digestion and liver functions [5-7]. *C. intybus* root continues to be a popular herbal remedy for its healing effects in several ailments include gastrointestinal discomfort, gallstones, gout and rheumatism, lowering the blood glucose and lipid, decreasing uric acid, and hepatoprotection [8-10]. The hepatoprotective effects of *C. scolymus* and *C. intybus* have been reported in experimental studies with different and some in very high doses [11-13]. In present study, however to find the hepatoprotective effect of *C. scolymus* leaf and *C. intybus* root extracts at lowest effective doses, three doses of 10, 20 and 30 times higher than average doses used in human herbal therapy were tested against CCl_4 induced liver toxicity in rats.

Materials and Methods

Animals

Eighty male Wistar rats aged 5 months and 230-250 g weight, were purchased from Shahid Beheshti University animal house, Tehran, Iran. The animals were maintained under a daily controlled 12 / 12 hr light dark cycle at 23°C and 50% humidity with free access to rat chow and water. The study was approved by the Institutional Animals Ethics Committee of ACECR, Tehran Iran.

Chemicals

Dimethyl sulfoxide (DMSO), ERBA test kits, sulphosalicylic acid, 5, 5'-dithio-bis (2-nitrobenzoicacid), ethylenediaminetetraacetic acid (EDTA), bovine serum albumin, CCl_4, GSH, 2-thiobarbituric acid, and other reagents of the highest grade were purchased from Sigma Chemical Co. (St. Louis, MO). Chemicals employed in these studies were reagent grade. All chemicals were used without further purification. CCl_4 was diluted two-fold in olive oil.

Plants material

C. scolymus leaf and *C. intybus* root were collected from institutional field. The extracts preparation was performed by Institute of Medicinal Plant Tehran Iran. Briefly the dry plants materials were powdered and immersed in hydro-alcoholic (80%) solvent for 24 hours and filtered. The procedure repeated twice more for complete extraction of the phytochemicals. Concentrate the filtrate in rotavapor at 50°C, and lyophilized to get dry extract. Three concentrations of 300, 600 and 900 mg/ml were prepared for *C. scolymus* leaf extract and three concentrations of 150, 300 and 450 mg/ml were prepared for *C. intybus* root extract by dissolving dry extracts in 5% DMSO in distilled water.

The above three doses are equally relative to 10, 20 and 30 times higher than average doses (2100 mg/day for *C. scolymus* leaf extract and 1050 mg/day for *C. intybus* root extract) used in human herbal therapy [3].

Experimental protocol

Administration of CCl_4 and medicinal plants extract

The rats were divided into eight groups of 10 animals each. One group was kept as normal and liver damage were induced in 7 groups by intra-peritoneal injection of 1 ml/kg body weight of 1:1 carbon tetrachloride in olive oil for two successive days by modified Zimmerman method [14]. Of 7 intoxicated

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]

groups one was kept as control and six different medicinal plants extracts were administered to remaining 6 groups. The medicinal plant extracts (dissolved in 5% DMSO in distilled water) were injected intraperitonealy for three days simultaneously with CCl_4 administration.

Experimental design

Normal group: Olive oil and DMSO as ***vehicles*** were administered intraperitoneally to this group for two and three days respectively.

Control group: DMSO as *vehicle* was administered intraperitoneally to this CCl_4 intoxicated group for three days.

***C. scolymus* groups:** *C. scolymus* root *extract* at the doses of 300, 600 and 900 mg/kg/day were administered separately to three groups for three days.

***C. intybus* groups:** *C. intybus* root extract at the doses of 150, 300 and 450 mg/kg/day were administered separately to three groups for three days.

Serum biochemical study

Three days after the liver intoxication **and** medicinal plants extracts treatment, the blood samples were collected from rat's heart under chloroform anesthesia. The serum liver enzymes such as serum ALT, AST, and ALP were estimated in all groups by International Federation of Clinical Chemistry (ERBA test kits) method [15, 16]. All enzymes activities are expressed as international units (IU/l).

Liver anti-oxidative study

Sample preparation

Immediately after the blood samples were collected under chloroform anesthesia, the animals were sacrificed and the residual bloods in liver as much as possible were removed by ice cold 0.9% NaCl perfusion and then livers were removed from the bodies. The isolated livers were weighed and kept at −80°C as soon as possible until further use. For the assays of hepatic GSH and catalase, a part of liver was homogenized in 9 volumes of ice-cold 0.15 M KCl containing 1.0 mM EDTA using a glass homogenizer with a Teflon pestle. The homogenate was sonicated on ice twice × 30 s and centrifuged at 12,000 × g for 15 min at 4°C. The supernatant was dialyzed against 100 volumes of the same buffered solution at 4°C for 60 min.

Determination of GSH level and catalase activity in liver tissue

The hepatic reduced GSH levels were determined by the method of Jollow et al. [17]. Briefly, the supernatant samples were kept at 4°C for at least 1 hour. The assay mixture contained 0.1 ml filtered aliquot, 2.7 ml phosphate/EDTA buffer (0.1 M, pH 7.4) and 0.2ml of 5,5'-dithio-bis (2-nitrobenzoic acid) in a total volume of 3.0 ml. The yellow color developed was read immediately at 412 nm on a spectrophotometer. At each determination, a standard curve of glutathione was prepared. The catalase activity was measured by Bergmeyer method [18]. The enzymatic method of H2O2 decomposition was used for determination of Catalase activity. Protein in liver tissue samples was measured by using bovine serum albumin as a standard according to method of Lowry et al. [19].

Determination of liver tissue histopathological injury

Small piece of liver were removed and fixed in 10% buffered formalin for 24 hour, then dehydrated in ascending grades of alcohol cleared in xylene and embedded in paraffin wax (58-60%) all in automatic tissue processors. Sections were cut at 3µm, double

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]

stained with hematoxylin - eosin and examined under the light microscope. The microvesicular steatosis and pericentral coagulation necrosis were determined as indication of CCl_4 induced liver injury. The microvesicular steatosis and pericentral coagulation necrosis were graded as grade 0 for no injury, grade 1 for low or below 30% injury, grade 2 for moderate or 30 - 60% injury and grade 3 for sever or above 60% injury [20].

Statistical analysis

All obtained values are expressed as the mean ± SD. All data were analyzed by computerized statistical packages (SPSS ver.11.5). Each mean value is compared by one-way analysis of variance and Tukey's post hoc test. The level of significance was set at <0.05.

Results

The serum liver enzymes levels, liver tissue GSH levels and catalase activities are given in table 1 and the data of liver histopathological injury are given in table 2.

Table 1– The serum liver enzymes levels and liver tissue catalase activities and GSH levels in normal and CCl_4 treated (control, *C. scolymus* and *C. intybus* treated groups) rats groups. All the values are expressed in terms of mean ± SD

Groups of 10 rats	Alanine transaminase (U/L)	Aspartate transaminase (U/L)	Alkaline phosphatase (U/L)	Glutathione (nM/mg protein)	Catalase (U/mg protein)
Normal	112 ± 23	63 ± 12	340 ± 57	22.87 ± 4.3	19.31 ± 4.1
Control	1561 ± 196	1225 ± 254	1200 ± 223	10.72 ± 1.0	13.29 ± 3.6
C. intybus 150 mg/kg/day	1431 ± 121	1221 ± 180	1116 ± 193	11.95 ± 1.8	13.38 ± 2.1
C. intybus 300 mg/kg/day	1445 ± 222	1024 ± 283	1101 ± 181	13.86 ± 2.4	14.51 ± 1.7
C. intybus 450 mg/kg/day	624 ± 51*	433 ± 60***	590 ± 46 ***	14.93 ± 2.7	13.80 ± 1.6
C. scolymus 300 mg/kg/day	1470 ± 109	1129 ± 203	1194 ± 230	12.43 ± 1.6	13.70 ± 2.8
C. scolymus 600 mg/kg/day	1262 ± 135	1100 ± 183	1112 ± 124	13.76 ± 1.0	14.65 ± 1.2
C. scolymus 900 mg/kg/day	861 ± 62 **	621 ± 133*	614 ± 40*	14.75 ± 1.9	14.03 ± 1.7

The data values of medicinal plants treated groups were compared to control group
$p<0.05^{*}$, $p<0.001^{**}$, $p<0.0001^{***}$

Table 2- The liver tissue histipathological injury parameters in normal and CCl_4 treated (control, *C. scolymus* and *C. intybus* treated groups) rats groups. All the values are expressed in terms of mean ± SD

Groups of 10 rats	Microvesicular Steatosis (grade 0 - 3)	Pericentral Coagulation necrosis (Grade 0 - 3)
Normal	0.222 ± 0.01	0.111 ± 0.01
Control	2.83 ± 0.40	2.50 ± 0.54
C. intybus 450 mg/kg/day	1.62 ± 0.74*	1.87 ± 0.99
C. scolymus 900 mg/kg/day	1.14 ± 0.37 **	1.28 ± 0.48*

The data values of medicinal plants treated groups were compared to control group
$p<0.05^{*}$, $p<0.0001^{**}$

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]

Serum liver enzymes

In control group, a significant increase in serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphates (ALP) concentration (1561 ± 196 U/l, 1225 ± 254 U/l and 1200 ± 223 U/l, respectively) were recorded three days after CCl_4 administration as compared to the normal group (112 ± 23 U/l, 63 ± 12 U/l and 340 ± 57 U/l respectively). The statistical results did not showed in Table 1.

In *C. intybus* root and *C. scolymus* leaf extract groups at the doses of 10 and 20 times of human doses (THD) the serum levels of liver enzymes did not differ as compared to the control group.

In *C. intybus* root extract group at the dose of 450 mg/kg/day (30 THD) the serum ALT, AST and ALP levels (624 ± 51, 433 ± 60 and 590±46 respectively) were significantly reduced ($p<0.01$, $p<0.0001$ and $p<0.0001$ respectively) as compared to the control group.

In *C. scolymus* leaf extract group 900 mg/kg/day (30 THD) the serum ALT, AST and ALP level (861 ± 62, 621 ± 133 and 614 ± 40 respectively) were significantly reduced ($p<0.001$, $p<0.05$ and $p<0.01$ respectively) as compared to the control group.

Liver tissue GSH level and catalase activity

In control group, a significant decrease in liver GSH and catalase activity observed three days after CCl_4 administration (10.72 ± 1.0 nmol/mg protein and 13.29 ± 3.6 U/mg protein respectively), that were significantly lowers as compared to the normal CCl_4-untreated group (22.87 ± 4.3 nmol/mg protein and 19.31 ± 4.1 U/mg protein respectively).

In both medicinal plants treated groups with different doses of plant extracts, liver GSH and catalase activity didn't differ significantly as compared to the control group (Table 1).

Liver histopathological injury

Severe microvesicular steatosis (MVS) and pericentral coagulation necrosis (PCN) were observed in the control group (2.83 ± 0.40 and 2.50 ± 0.54 respectively), which was significantly lower compared to the normal group (0.222 ± 0.01 and 0.111 ± 0.01 respectively). The MVS and PCN were not determined in *C. intybus* root and *C. scolymus* leaf extract treated groups at the doses of 10 and 20 THD due to high serum liver enzyme levels same as control group.

The MVS in *C. intybus* root and *C. scolymus* leaf extract treated groups with 30 THD (1.62 ± 0.74 and 1.14 ± 0.37 respectively) decreased significantly ($p= 0.04$ and $p< 0.001$ respectively), as compared to the control group. The PCN was reduced in both medicinal plants extract treated groups. However, it was reduced (1.28 ± 0.48) statistically significant ($p= 0.029$) in *C. scolymus* as compared to the control group.

Discussion

Carbon tetrachloride is a well-known hepatotoxin and exposure to this chemical induced oxidative stress to many body tissues evidenced by deactivation of superoxide dismutase, catalase, and glutathione peroxides enzymes [21, 22]. CCl_4 induced acute liver injury is characterized by liver cell necrosis and steatosis resulting in serum elevation of the alanine aminotransferase, aspartate aminotransferase and alkaline phosphatase levels [14].

In the present study, CCl_4 administration to rats induced severe hepatic tissue injury evidenced as microvesicular steatosis and pericentral coagulation necrosis as well as significantly elevated serum liver enzymes level and decrease in hepatic anti-oxidative activity. *C. scolymus* leaf and *C. intybus* root

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]

extracts treatment to CCl_4 intoxicated rats at 10 and 20 times of human doses (THD) did not influence the liver toxicity, where as at higher doses i.e. 30 THD administration of these medicinal plants extracts attenuated the decrease in liver toxicity as indicated by serum liver enzymes level lowering effect and amelioration in histopathological changes in the liver tissue. However, we failed to observe any effect of *C. scolymus* leaf and *C. intybus* root extracts on liver tissue GSH level and catalase activities. The underlying mechanism for hepatoprotective effects of *C. scolymus* leaf and *C. intybus* root extract remains to be elucidated.

In *C. scolymus* leaf extract several compounds such as cynarin, caffeic acid, chlorogenic acid, luteolin and other flavonoids and polyphenol compounds, some with antioxidant properties have been found [23-25]. Adzet T et al., reported that, the hepatoprotective effect of *C. scolymus* may be due to its chlorogenic acid and cynarin content [12] and other study proposed that, the protective effect of *C. scolymus* leaf extract on CCl_4 induced acute liver injury may be due to its antioxidative property [25]. In *C. intybus* root a phenolic compound esculetin, is known for anti-hepatotoxic activity [10, 26]. Zafar R, and Mujahid Ali S. proposed that, the hepatoprotective effect of *C. intybus* root extract may be due to its ability to suppress the oxidative degradation of DNA in the tissue debris [13].

However, in present study we observed the liver protective activity of *C. scolymus* leaf and *C. intybus* root extracts without significant effect on the liver tissue GSH level and catalase activity as markers of body anti-oxidative defense system. This indicate that the observed protective effects on CCl_4 induced liver injury in this study may not be due to anti-oxidative activities of the two extracts only, as demonstrated in other studies [14, 22].

Overall, to explain the observed hepatoprotective effects of *C. scolymus* leaf and *C. intybus* root extract in the present study, it is important to remember that following CCl_4 induced acute liver injury; several important basic mechanisms such as reactive free radical metabolites formation, lipid peroxidation, covalent binding and disturbance of calcium homeostasis are involved in tissue damage [27]. In addition, inflammation and regeneration are other important modifying factors in the tissue injury [27]. However, the observed effects of *C. scolymus* leaf and *C. intybus* root extract against CCl_4 intoxication in present study may be due to the direct or indirect favorable effect of medicinal plants on liver cellular metabolism, inflammation and regeneration.

Conclusion

The present findings indicated that, the administration of *C. scolymus* L. leaf and *C. intybus* L. root extract at the doses of 900 mg/kg/day and 450 mg/kg/day respectively or 30 THD to CCl_4 intoxicated rats, prevent liver toxicity and liver histopathological changes without significant influence on hepatic antioxidant properties. Further studies are required to evaluate the efficacy of combined administration of both medicinal plant extracts at different doses in experimental studies.

Acknowledgements

This study was supported by a research Grant # 1297-33-24/8/1388 from the ACECR Deputy Research Tehran, Iran. We thank the administration of the Institute of Medicinal Plants for their support in providing the necessary facilities for conducting this study.

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]

References

1. Schuppan, Jia DJ, Brikhaus B, Hahn EG. Herbal products for liver disease: A therapeutic challenge for the new millennium. *Hepatology* 1999; 30: 1099 - 104.

2. Chevallier A. The Encyclopedia of Medicinal Plants. New York, NY: DK Publishing. 1996, pp: 96 - 7.

3. Haji Sharifi A. *Cynara scolymus* L. *Cichorium intybus* L. In Secrets of Herbal Medicine. Noskh-e-Shafa. 3rd ed. Hafez Novin Press. Tehran Iran. 2003, 820 - 59.

4. Compilation Committee of Iranian Herbal Pharmacoepia. *Cynara scolymus* L. *Cichorium intybus* L. In Iranian Herbal Pharmacoepia. Vol. 2, Ministry of Health and Medical Education, Tehran Iran. 2002, pp: 582 - 669.

5. Bundy R, Walker AF, Middleton RW, Wallis C, Simpson HC. Artichoke leaf extract (*Cynara scolymus*) reduces plasma cholesterol in otherwise healthy hypercholesterolemic adults: a randomized, double blind placebo controlled trial. *Phytomedicine* 2008; 15: 668 - 75.

6. ESCOP (Europian Scientefic Corporative On Phytotherapy), Monographs. The Scientific Foundation of Herbal Medicinal Products- cyanara folium, artichoke leaf: Thieme, 2003, pp: 118 - 25.

7. Kraft K. Artichoke leaf extract. Recent findings reflecting effects on lipid metabolism, liver and gastrointestinal tracts. *Phytomedicine* 1997; 4 (4): 369 - 78.

8. Ripoll C, Flourié B, Megnien S, Hermand O, Janssens M. Gastrointestinal tolerance to an inulin-rich soluble roasted chicory extract after consumption in healthy subjects. *Nutrition* 2009; 18: 799 - 803.

9. Howard, M. Traditional Folk Remedies. United Kingdom, David & Charles, Publishing. 1987, p. 120.

10. Wang Q, Cui J. A review on pharmic effect of chicory research and development. *Zhongguo Zhong Yao Za Zhi.* 2009; 34 (17): 2269 - 72.

11. Speroni E, Cervellati R, Govoni P, Guizzardi S, Renzulli C, Guerra MC. Efficacy of different *Cynara scolymus* preparations on liver complaints. *J. Ethnopharmacol.* 2003; 86 (2-3): 203 - 11.

12. Adzet T, Camarasa J, Laguna JC. Hepatoprotective activity of polyphenolic compounds from *Cynara scolymus* against carbon tetrachloride toxicity in isolated rat hepatocytes. *J. Nat. Prod.* 1987; 50: 612 - 17.

13. Zafar R, Mujahid Ali S. Anti-hepatotoxic effects of root and root callus extracts of *Cichorium intybus* L. *J. Ethnopharmacol*. 1998; 63 (3): 227 - 31.

14. Zimmerman H J. Hepatotoxicity. The adverse effects of drugs and other chemicals on the liver. In: Carbon Tetrachloride. New York: Appleton-Century-Crofts, 1979, pp: 198 - 217.

15. International Federation of Clinical Chemistry and Laboratory Medicine (IFCC). Methods for the measurement of catalytic concentrations of enzymes. Part 3. IFCC method for alanine aminotransferase. *Clin. Chim. Acta*. 1980; 105: F145 – 72.

16. Recommendations of the German Society for Clinical Chemistry. Standardisation of methods for the estimation of enzyme activities in biological fluids. Experimental basis for the optimized standard conditions. *Z. Klin. Chem. Klin. Biochem*. 1972; 10: 281 –

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]

91.

17. Jollow DJ, Mitchell JR, Zampaglione N, Gillette JR. Bromobenzene-induced liver necrosis. Protective role of glutathione and evidence for 3,4-bromobenzene oxide as the hepatotoxic metabolite. *Pharmacology* 1974; 11 (3): 151 - 69.

18. Bergmeyer H.U. Zur Mesung von Katalase-Activitäten. *Biochem. Zeit.* 1955; 327: 255 – 8.

19. Lowry OH, Rosebrough NH, Farr AD, Randall RJ. Protein measurement with the Folin reagent. *J. Biol. Chem.* 1951; 193: 265 – 73.

20. Kumar V, Abbas AK, Fausto N. Pathologic Basis of disease.7th ed. Philadelphia, Saunders. 2005, pp: 25 - 6.

21. Ahmad FF, Cowan DL, Sun AY. Detection of free radical formation in various tissues after acute carbon tetrachloride administration in gerbil. *Life Sci.* 1987; 41 (22): 2469 - 75.

22. Szymonik-Lesiuk S, Czechowska G, Stryjecka-Zimmer M, Słomka M, Madro A, Celiński K, et al. Catalase, superoxide dismutase, and glutathione peroxidase activities in various rat tissues after carbon tetrachloride. *J. Hepato. Biliary Pancreat. Surg.* 2003; 10 (4): 309 - 15.

23. Gebhardt R. Antioxidative and protective properties of extracts from leaves of the artichoke (*Cynara scolymus* L.) against hydroperoxide-induced oxidative stress in cultured rat hepatocytes. *Toxicol. Appl. Pharmacol.* 1997; 144 (2): 279 – 86.

24. Wang M, Simon JE, Aviles IF, He K, Zheng QY, Tadmor Y. Analysis of antioxidative phenolic compounds in artichoke (*Cynara scolymus* L.). *J. Agric. Food Chem.* 2003; 51 (3): 601 - 8.

25. Jiménez-Escrig A, Dragsted LO, Daneshvar B, Pulido R, Saura-Calixto F . *In vitro* antioxidant activities of edible artichoke (*Cynara scolymus* L.) and effect on biomarkers of antioxidants in rats. *J. Agric. Food Chemi.* 2003; 51 (18): 5540 - 5.

26. Gadgoli C, Mishra SH. Antihepatotoxic activity of *Cichorium intybus*. *J. Ethnopharmacol*. 1997; 58 (2): 131 - 4.

27. Masuda Y. Learning toxicology from carbon tetrachloride-induced hepatotoxicity. *Yakugaku Zasshi* 2006; 126 (10): 885 - 99.

[Downloaded from jmp.ir on 2026-11-18]

[DOR: 20.1001.1.2717204.2011.10.37.4.5]