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Study the Effect of Artichoke-Supplemented Tofu Cheese on Liver Toxicity in Rats.

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ABSTRACT:

The present study was designed to evaluate the effect of artichoke-supported tofu cheese on liver toxicity in rats induced by CCl4. Thirty male albino rats (weighing 150 ± 10 g) were divided into six groups of five rats each. The first group (n = 5) remained a negative control group. The second group (n = 25) was induced liver toxicity by administering 0.5 ml of a 1:1 mixture of CCl4 and olive oil twice a week for 2 weeks based on calculated values (2 ml/kg b.wt.) to induce liver damage. The induced rats were randomly divided into five groups (n = 5) as follows: group (2) was kept as a positive control, group (3) was fed on 2.5 % tofu cheese supported with 0.4 artichokes from the basal diet, group (4) was fed on 5 % tofu cheese supported with 0.4 artichokes, group (5) was fed on 2.5% tofu cheese supported with 0.6 artichokes, and group (6) was fed on 5% tofu cheese supported with 0.6 artichoke. The experiment lasted for 28 days. At the end of the experimental period, each rat was slaughtered to collect blood samples of liver and kidney functions, lipid profile, and serum glucose levels. A histopathological examination of the liver was also performed. The biochemical study's findings demonstrated a significant ($p \leq 0.05$) improvement in the analyses and liver histopathological examination, demonstrating the superiority of the treatments backed by 0.6 artichokes. Thus, our findings demonstrate using artichoke-supported tofu cheese in our regular meals.

Keywords: Hepato-Protective Effect, Soybean, Functional Food, Rats

1. INTRODUCTION

The liver is the largest organ in the body, contributing about 1.5 kg to the average adult human. The liver performs many different functions, yet it is also a discrete organ and many of its functions are interrelated. This becomes especially evident in abnormalities of the liver such as hepatitis, jaundice, toxicity, and cirrhosis (1). Occupational and environmental liver illnesses can cause a wide range of symptoms, from asymptomatic elevated liver enzymes to acute liver failure, cirrhosis, and cancer. Most industrial chemicals, including solvents, may cause hepatocellular

necrosis and have dose-dependent hepatocyte cytotoxicity (2). The liver, being a vital organ, is frequently subjected to various dangers. The liver's functioning can deteriorate because of injury, which can lead to organ failure (3). Liver diseases are the fifth biggest killer after cancer, stroke, and respiratory disease. Chronic hepatitis B and C, alcohol, nonalcoholic steatohepatitis linked to obesity, and metabolic syndrome are the most common causes of liver disease globally. (4). With up to 83% of all cases and the most severe issues, liver toxicity is currently among the most prevalent diseases in the world. Regardless, oxidative stress and reactive oxygen compounds are believed to play a significant role in the onset and progression of liver problems, independent of the primary etiologic agent. Carbon tetrachloride, also known by the chemical name CCl4, is a substance that specifically harms the liver. The cytochrome P450 breaks it down into extremely reactive metabolites, including the other two compounds, 3-chloro-methyl free radicals and 3-chloro-methyl peroxy radicals. (5). When cytochrome P450 breaks down carbon tetrachloride in the liver's cells' endoplasmic reticulum, a defective product of the CCl3 radical is produced. This radical quickly interacts with oxygen to make the extremely reactive and liver-damaging trichloromethyl peroxy radical (6). Liver disease treatment is significantly impacted by conventional, natural medicine. While several additional substances are believed to possess liver-protective and hepato-curative activity, numerous natural plant nutrients are efficient hepato-protective agents (7). Naturally product-driven plant nutrients are thought to represent the most trustworthy and effective source for creating new medicinal products, but due to their low intake, dispersion, metabolic processes, and eradication, as well as their limited toxicological characteristics, their medical application is still limited. Scientists and academics have become increasingly motivated in recent years to discover novel liver-protective compounds from plant sources to create cutting edge treatments for a variety of hepatic problems (8). Patients with chronic liver disease follow a standard diet consisting of functional foods to ensure they consume enough calories and protein to make up for any nutrient deficiencies. (9). Researchers have been exploring the health benefits of various foods as a natural way of treating or preventing diseases. These beneficial sources include saturated fat, protein, and dietary fiber, among others. Soybeans, in particular, are a great source of antioxidants that help protect cells from free radicals they also play a crucial role in regulating kidney and liver function (10) Proteins, carbohydrates, vitamins, and minerals are just a few of the many advantageous elements found in soy, an oilseed that is well-suited for plants and

vegetarian diets (11). It is rich in many beneficial nutrients. It can also be prepared with a variety of fermented and unfermented soy products. Tofu cheese, cereals, milk drinks made from soy, and processed soy products should be avoided, and daily consumption of soy products should be limited to no more than 1 to 3 grams (12). Pharmacological properties of soybeans and phytochemicals include hepato-protective, anti-oxidant, estrogenic, anti-diabetic, anti-hypercholesterolemic, anti-hyperlipidemic, anti-obesity, antihypertensive, anti-cancer, anti-mutagenic, anto-steoporotic, anti-virus, anti-dromic, anti-pyrine, anti-aging, anti-phonic activity, and effects of malnutrition (13). These pharmacological properties of soy are largely due to the presence of isoflavones in soy (14). Additionally, the study found that adding herbs to cheese, such as black seed, artichokes, and spices, improves the cheese's nutritional value, lengthens its shelf life, and improves the quality and nutritional value of sour cheese when compared to unsorted cheese (15).

Therefore, the purpose of our research was to determine how artichoke-supported tofu cheese affected rats' liver toxicity caused by CCl4.

2. Material and Methods

2.1. Materials

Purchased fresh artichokes and soybeans from the Menoufia Governorate, Egypt, local market

Carbon tetrachloride (CCl4) in 10% liquid solution was purchased from Al-Gomhoria Company for Trading Drugs, Chemicals, and Medical Industries, Cairo, Egypt.

Thirty albino rats, body weight (150 ± 10 g), were obtained from the Institute of Nutrition, Cairo, Egypt.

2.2 Methods

Whole artichokes were hand-washed, divided into small pieces, and then air-dried for 24 hours at 45°C in an oven for drying (plus a paring oven, T.S 100, Taiwan). The electric-powered stainless-steel grinder (Braun, 537, Germany) was used to grind the dried materials and keep them in Polyethylene bags, which were then frozen at -4°C until needed (16).

2.2.1 Manufacture of Tofu cheese

Fresh soybeans were soaked in clean water for 8-10 hours, to get rid of impurities , 0.1gram of bicarbonate of soda per 1kg of the beans were mixed well using the electric mixer, to obtain a white mixture, Then it was passed through a fine strainer, to separate the milk from impurities and solid part and artichoke powder was add Finally heat the filtered milk to 37 ° C for 15-20 minutes, then citric acid was added as a coagulant and left to boil for 5 minutes, after which it was left to cool to obtain The tofu curds were cut into small pieces in a whey yellow liquid, then the cheese curds were pressed Three hours to get rid of the serum, that's when the tofu cheese was obtained according to A.O.A.C, 2014(17).

2.2.2 Chemical Analysis of Soybean Cheese

To analyze the content of cheese, several methods were used (18). Drying 10 grams of cheese at 105 °C in an electric oven until a constant weight was reached was the method used to measure the moisture content. Using the direct burning method (19), the ash content was estimated. Using the Gerber method (20), the amount of fat in the cheese was calculated and the percentage was taken from the fat column. The total nitrogen ratio was multiplied by a 6.25 (21) conversion factor to determine protein content. Finally, the difference method (22), which computes the carbohydrate ratio, was applied.

2.2.3 Sensory evaluation of cheese

Using the sensory evaluation schedule suggested by Tietz, 2005 (23), a specialist of lecturers from the Department of Nutrition and Food Science at the Faculty of Home Economics evaluated each cheese transaction using their senses.

2.2.4 Experimental design

The search was conducted at the animal house of the Faculty of Home Economics at Menoufia University in Egypt. The Department of Nutrition and Food Science in the College of Home Economics has received ethical approval from the Scientific Research Ethics Committee of the College of Home Economics and issued Research Protocol No. 14-SREC-03-2022. Rats were kept in wire cages at a constant temperature of 25 °C and under normal, healthy circumstances. In this study, thirty albino rats, all male, weighed 150 ± 10 g.

Two major groups of rats were randomly assigned

The first group is the negative control group. Group 1:: (n =5) fed standard diet only.

The second main group is induced rats (n = 25). Rats in this group received 0.2 ml of CCl4 injections per 100 g of body weight. Rats that were induced were split into 5 subgroups, each with 5 rats, based on the following:

Group 2: (n=5) Induced rats were fed on a basal diet.

Group 3: (n=5): fed on 2.5 % Tofu cheese supported with 0.4 artichoke powder (AP) from the basal diet.

Group 4: (n=5) was fed on 5% Tofu cheese supported with 0.4 AP from the basal diet.

Group 5: (n=5): Inducing rats fed Tofu cheese supported with 0.6 AP from the basal diet.

Group 6: (n=5): inducing rats fed Tofu cheese supported with 0.6 AP from the basal diet.

For a total of 28 days, the experiment was conducted. After a 12-hour fast, each rat was killed at the end of the experiment to obtain blood samples, and at the conclusion of each trial, blood samples were taken from the hepatic portal vein. Following the drawing of blood samples into clean, dry centrifuge tubes and their 30-minute clotting in a 37°C water bath, the serum was extracted from the samples

by centrifuging them for 10 minutes at 4000 rpm. According to Schermer,1967 (24).

2.2.5 Biochemical analysis

Liver functions

Serum concentrations of each liver enzyme, including alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP), were evaluated (25, 26, 27) as described in the methods described.

Kidney functions

In the enzymatic method, serum urea was measured (28). The calorimetric method of was used to measure serum uric acid concentration (29) .Creatinine was measured using the kinetic method of Schirmeister,1964(30).

Serum lipid profile

Total cholesterol (TC), triglycerides (TG), and high-density lipoprotein (HDL) were determined according to references (31), (32), and (33) respectively. Low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) were calculated as per the methods outlined in (34).

Serum glucose

Blood glucose was measured enzymatically by Kaplan method (35).

2.2.6 Statistic evaluation

When a significant main effect was found, the data were analyzed using a fully randomized factorial design (36). The Student-Newman Keuls test means were distributed, and the Costas Program was used to confirm that differences between treatments at P≤ 0.05 were statistically significant. The biological effects were evaluated using a one-way ANOVA analysis of variance.

3. Results and Discussion

Table 1 presents the chemical composition of soybean cheese and artichoke-supported soybean cheese. The study found that the moisture content was 72.2%, protein 12.6%, fat 3.9%, ash 0.72%, and carbohydrates 4.34%. These results support the findings of previous studies (37), which showed a decrease in moisture values compared to the control group, most likely due to the addition of citric acid, which reduced pH values. As compared to the control group, the percentages of protein, fat, and ash have somewhat increased. This could be because the lower pH levels have led to a decrease in humidity.

Table (1): The chemical composition of both soybean cheese and artichoke-supported soybean (%)

	Moisture	Protein	Fats	Carbohydrate	Ash
Control	72.2	12.6	3.9	4.34	0.7
Sample 1	62.2	11.9	3.85	4.33	0.71
Sample 2	54.4	10.5	3.85	4.28	0.73

the numbers in the table refer to three-repeat rates. Cheese with concentrated artichokes (0.4/100g) as sample 1. Cheese with concentrated artichokes (0.6/100g) as sample 2.

The impact of cheese consumption accompanied by AP on liver functions in rats given CCl4 was examined in Table 2. The findings indicated that CCl4 could alter the level of liver biochemical markers by raising serum levels of alkaline phosphatase (ALP), aspartate aminotransferase (AST), and alanine aminotransferase (ALT), with percentage changes of 45.77%, 34.05%, and 33.075%, respectively. according to (38). Cynarin, also referred to as phenolin, is one of the primary essential compounds found in artichokes and is essential for treating liver issues. They clarified that artichokes, especially in the case of liver disorders, have a variety of advantageous qualities that can enhance general health without having any negative effects (39). According to this line, artichokes may lower MDA and liver enzyme levels, such as AST, ALT, and ALP (40). additionally, This review article gives an idea of functional foods from the chemical and nutritional point of view. Also, the effect of some functional foods such as artichoke, milk thistle, turmeric and gum Arabic on the prevention and/or treatment of some diseases such as liver diseases (41).

Table (2): Effect of AP- supported tofu cheese on liver functions in ccl4 inducing rats.

	ALT (U/L)	% of change	AST (U/L)	% of change	ALP (U/L)	% of change
G1 C (-)	24.60f±1.13	45.87	115.60e±2.1	34.05	187.60e±2.6	33.07
G2 C (+)	45.45a±1.65	00	175.30a±3.11	00	280.30a±4.28	00
G3 (2.5% tofu cheese with 0.4	41.52b±1.34	-8.65	151.50b±2.74	-13.57	240.32b±4.10	-14.26
G4 (5% tofu cheese with 0.4	39.28c±1.37	13.57	140.26c±2.50	-19.98	229.64c±3.75	-18.13
G5 (2.5% tofu cheese with 0.6	36.30d±1.12	-20.13	139.34c±2.31	-20.51	236.18b±3.62	-15.74
G6 (5% tofu cheese with 0.6	30.39e±1.27	-33.13	128.65d±2.10	-26.61	203.61d±3.00	-27.35
LSD (P≤0.05)	1.460		3.172		4.260	

Each value represents the mean ± SD of three replicates. Means in the same column with different letter are significantly different (P<0.05). AST: Aspartate amino transferase. ALT: Alanine aminotransferase. ALP: Alkaline phosphatase.

The data presented in Table (3) shows the effect of tofu cheese with AP on the kidney functions (urea, uric acid, and creatinine) of induced rats. In this study, it was found that giving rats CCl4 resulted in a noticeable rise in their serum urea, uric acid, and creatinine levels in the positive control group compared to the negative control group. The results showed that the values for urea, uric acid, and creatinine for the positive control group were 56.04, 46.72, and 66.45, respectively. As per earlier research (42) Both fiber and phenolic compounds are abundant in artichokes. These compounds has the potential to prevent kidney disease among other illnesses (43). Table (4.5) displays the data about the impact of tofu cheese supported by AP on the lipid profile (HDL-c, LDL-c, VLDL-c, T.C., and T.G.) of rats that were given CCl4 injections. The results showed a significant increase (p≤0.05) in serum T.C., T.G., and LDLc with a percentage change of 49.60, 50, and 79.59, respectively, when compared to negative

control. In contrast, when compared to the control (-), CCl4 administration resulted in a significant (p≤0.05) decrease in HDLc with a percentage change of 82.37.

Table (3): Effect of AP-supported tofu cheese on kidney function in ccl4 induced rats :

	Urea mg/dl	% of change	Uric acid mg/dl	% of change	Creatinine mg/dl	% of change
G1 C (-)	18.80f±0.55	56.04	4.63c ±0.30	46.72	0.53b±0.21	66.45
G2 C (+)	42.77a±1.43	00.00	8.69a±1.20	00.00	1.58a±0.34	00.00
G3(Tofu cheese supported with 0.4 AP)	36.15b±0.20	-15.47	7.61b±0.28	-12.39	0.91b±0.04	-42.40
G4 (Tofu cheese supported with 0.4 AP	31.26c±0.40	-26.91	5.53c±0.40	-36.36	0.75b±0.04	-52.53
G5 (Tofu cheese supported with 0.6 AP)	30.25e±0.27	-29.27	5.22c±0.29	-39.93	0.74b±0.02	-53.16
G6 (Tofu cheese supported with 0.6 AP)	24.18e±0.33	-43.46	5.20d±0.02	-40.16	0.62b±0.02	-60.75
LSD (P≤0.05)	1.33		0.89		0.25	

Each value represents the mean ± SD of three replicates. Means in the same column with different letter are significantly different (P<0.05).

Rats' serum lipid profile was significantly improved (p≤0.05) after receiving tofu cheese supported by AP at concentrations of 0.4 and 0.6% in comparison to the positive group. With a percentage change of 38.32, 34.49, and 65.72 for total cholesterol levels, triglycerides, and LDLc, respectively, group six (5% tofu cheese supported with 0.6 AP) had the best results among the treated groups. There was also a significant increase (p≤0.05) in HDLc, with a percentage change of -71.01, when compared to the positive control group. A recent study found that adults with high blood cholesterol who regularly take artichoke tablets have higher levels of "good" cholesterol. This is because these tablets contain a compound called luteolin-7-**β**-D-rutinoside, which is an antioxidant that stops the formation of cholesterol. The results of this study are consistent with previous research (44). which discovered that artichokes contain antioxidants, phenolics, fiber, volatile fatty acids, and polyunsaturated fatty acids. Artichokes are believed to be effective in reducing arteriosclerosis by decreasing the production of triglycerides and acids in the dark, which in turn reduces their levels in the serum. This may be due to a decrease in active compounds present in soybean plants, such as soy saponin and isoflavone, which contain alcohol-soluble aglycones and glycosides (45). This study demonstrated how artichoke powder, which has been touted for its antioxidant properties, can reduce peptic ulcer (46).

Data presented in Table 6 show the effect of tofu cheese supported with AP on the serum glucose level of induced rats. The data showed that the highest value was recorded in the positive control group compared to the negative control group, with a significant difference (P < 0.05).

Table (4): Effect of AP- supported with tofu cheese on TC and TG in ccl4 inducing rats.

	Total cholesterol (mg/dl)	% of change	Triglycerides (mg/dl)	% of change
G1 C (-)	96.00f ±2.06	49.60	79.00e ± 1.77	50
G2 C (+)	190.50a ±2.65	00.00	158.00a ± 2.43	00.00
G3(Tofu cheese supported with 0.4 AP)	161.50b ±2.27	-15.22	132.50b ± 2.27	-16.13
G4 (Tofu cheese supported with 0.4 AP	145.00c ±2.13	- 23.88	130.50b±2.14	-17.40
G5 (Tofu cheese supported with 0.6 AP)	139.00d ±2.25	-27.03	121.50c ± 2.28	-23.10
G6 (Tofu cheese supported with 0.6 AP)	117.50e ±2.11	-38.32	103.50d ± 2.01	-34.49
LSD (P≤0.05)	2.841		2.650	

Each value represents the mean ± SD of three replicates. Means in the same column with different letter are significantly different (P<0.05).

Table (5): Effect AP-supported tofu cheese on HDL , LDL and VLDL in ccl4 inducing rats.

Parameters Groups	HDL-C (mg/dl)	% of change	LDL-c (mg/dl)	% of change	VLDL-c (mg/dl)	% of change
G1 C (-)	53.8a±1.35	-82.37	26.4f±1.74	79.59	15.2e±0.28	51.96
G2 C (+)	29.5e±1.77	00.00	129.4a±1.97	00.00	31.6a±0.72	00.00
G3(Tofu cheese supported with 0.4 AP)	45.2d±1.27	53.22	89..8b±1.12	-30.60	26.5b±0.53	-16.13
G4 (Tofu cheese supported with 0.4 AP	48.5c±1.32	64.40	72.0c±1.46	-44.35	26.1b±0.56	-17.40
G5 (Tofu cheese supported with 0.6 AP)	47.9c±1.41	62.37	65.0d±1.23	-49.76	24.5c±0.45	-22.46
G6 (Tofu cheese supported with 0.6 AP)	50.45b±1.54	71.01	44.35e±1.06	-65.72	20.7d±0.37	-34.49
LSD (P≤0.05)	1.054		1.470		0.842	

Each value represents the mean ± SD of three replicates. Means in the same column with different letter are significantly different (P<0.05). HDL-c= High density lipoprotein cholesterol. 'LDL-c =Low density lipoprotein cholesterol. VLDL-c = Very low-density lipoprotein cholesterol.

The mean values were 125.45 and 108.00 mg/dL. Compared to the positive control group, the treated groups that received 5% tofu cheese showed the greatest effect, as evidenced by a 0.6 AP average of 84.00 mg/dL. With a mean value of 118.16 mg/dl, the 2.5% tofu cheese supported by the 0.4 AP-treated group had the lowest sugar content.

However, soy and artichoke cheeses contain phenolic acids, specifically caffeic acid, which is derived from caffeoylquinic acid (47).

Eating cooked artichokes with a meal was shown to lower blood sugar and increase insulin sensitivity within 30 minutes of consumption (48). According to this line feeding rats a mixture of tofu and some fruits increased their relative body weight gain, decreased the relative weight of organs, lowered serum glucose (49).

Evaluation of the liver' histopathology:

Microscopically, the liver of a rat from group 1 showed the normal histological structure of hepatic lobule (Photo.1). However, liver of rat from group 2 showed focal hepatic necrosis associated with inflammatory cell infiltration as well as sinusoidal leukocytosis (Photo.2). Meanwhile, the liver of rat from group 3 showing cytoplasmic vacuolization of hepatocytes (Photo.3).

Table (6): Effect of AP- supported tofu cheese on Glucose serum in ccl4 inducing rats.

	Glucose level (mg/dl)	% of change
G1 C (-)	108.00d ±3.18	13.90
G2 C (+)	125.45a ±1.64	00.00
G3(Tofu cheese supported with 0.4 AP)	118.16a ±1.20	5.81
G4 (Tofu cheese supported with 0.4 AP	114.35b±2.83	8.84
G5 (Tofu cheese supported with 0.6 AP)	95.60b±2.75	23.79
G6 (Tofu cheese supported with 0.6 AP)	84.00d ±4.25	33.04
LSD (P≤0.05)	4.170	

Each value represents the mean ± SD of three replicates. Means in the same column with different letter are significantly different (P<0.05).

Liver of rat from group 4 showing Kupffer cells activation and congestion of hepatic sinusoids (Photo.4). However, liver of rat from group 5 showing slight congestion of hepatic sinusoids and binucleation of hepatocytes (Photo.5). Liver of rat from group 6 showing the normal histological structure of hepatic lobule (Photo.6).

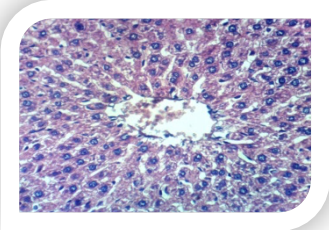

Photo (1): Liver of rat from group (1) showing the normal histological structure of the hepatic lobule (H & E X 400).

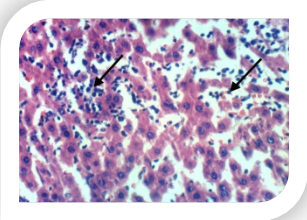

Photo (2): Liver of rat from group (2) showing focal hepatic necrosis associated with inflammatory cells infiltration as well as sinusoidal leukocytosis (H & E X 400).

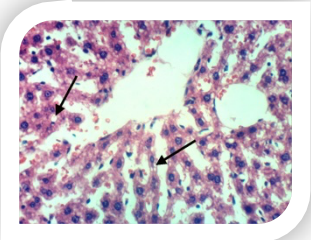

Photo (3): Liver of rat from group (3) showing cytoplasmic vacuolization of hepatocytes (H & E X 400).

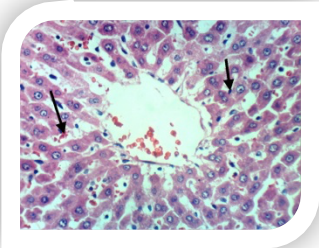

Photo (4): Liver of rat from group (4) showing Kupffer cells activation and congestion of hepatic sinusoids (H & E X 400).

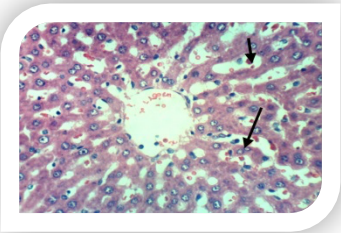

Photo (5): Liver of rat from group (5) showing slight congestion of hepatic sinusoids and binucleation of hepatocytes (H & E X 400).

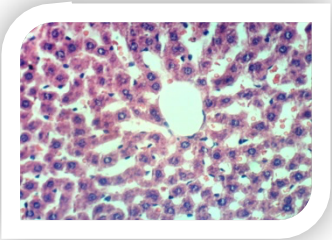

Photo (6): Liver of rat from group (6) showing the normal histological structure.

4 Conclusion

Our research showed that feeding tofu cheese fortified with artichoke powder in experimental animals led to a signification therapeutic impact on rats with ccl4 inducing rats, as evidenced by an improvement in the profiles of the liver, kidney, lipids, glucose, and histopathological examination fractions as compared to the positive control group. so we can recommend the utilization of tofu cheese supported with artichoke powder in our regular dishes, which demonstrates the potent nutraceutical therapeutic advantages of consuming artichoke and soybeans, both separately and together, to improve liver toxicity.

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التغذية وعلوم الاطعمة

دراسة تاثير جبن التوفو المدعمة بالخرشوف على سمية الكبد في الفئران.

يمنى مرعى، سهام خضر، وفاء رفعت

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الملخص العربى:

صممت الدراسة الحالية لتقييم تأثير جبن التوفو المدعمة بالخرشوف على سمية الكبد في الفئران المستحثه بمركب رابع كلوريد الكربون. تم تقسيم ثلاثين ذكراً من الفئران البيضاء بوزن (150 ± 10 جرام) إلى ستة مجموعة من خمسة فئران لكل منها. تم الاحتفاظ بالمجموعة الأولى (العدد = 5) كمجموعة ضابطه سلبية، أما المجموعه الثانية (العدد = 25) فقد تم حقنها برابع كلوريد الكربون بنسبه (0.5 مل من خليط 1: 1 من رابع كلوريد الكربون وزيت الزيتون) على أساس حساب (2 مل / كجم من وزن الجسم) مرتين في الأسبوع لمدة أسبوعين للحث على تلف الكبد. تم تقسيم المجموعه المصابه الى 5 مجاميع فرعيه (العدد = 5) كما يلي: المجموعة (2): تم الاحتفاظ بها كمجموعة سيطرة موجبة، المجموعة (3): تغذت على 2.5% جبن التوفو مدعمة بـ 0.4 خرشوف من الغذاء الاساسى، المجموعة (4): تغذت على5% جبن توفو مدعم بـ 0.4 خرشوف من الغذاء الاساسى المجموعة (5): تغذت على 2.5% جبن توفو مدعم بـ 0.6 خرشوف من الغذاءالأساسى المجموعة (6): تغذت على 5% جبن توفو مدعم بـ 0.6 خرشوف من الغذاء الاساسى ، واستمرت التجربة 28 يوماً. في نهاية الفترة التجريبية تم وزن كل فأرعلى حدة، وتم تشريح الفئران لجمع عينات الدم لاجراء الفحوصات المختلفه من وظائف الكبد، وظائف الكلى، مستوى الدهون ومستوى السكر في الدم. كما تم تحديد الفحص الهستوباثيولوجى للكبد . أظهرت نتائج الدراسة الكيموحيوية تحسنا معنوياً ($p<0.05$) في التحاليل والفحص الهيستوباثيولوجى للكبد تفوق المعاملات المدعمة بـ 0.6 خرشوف . لذلك تشير دراستنا إلى أنه يمكن التوصية باستخدام جبن التوفو المدعم بالخرشوف في أطباقنا العادية.

الكلمات المفتاحية: أوراق الغار، المستخلصات، الفئران، مرض السكر.