Attenuative Effects of Avocado (*Persea americana Mill*) and Kiwi (*Actinidia deliciosa*) Fruits Juice Against Cadmium Induced Hepatotoxicity in Rats

Nada Hassan Shaykhoun[1], Ahmed Ali Ameen[2], Shaimaa H. Negm[3]

1: Nutrition and Food Science Department, Faculty of Home Economics, Helwan University.

2: Faculty of Nutrition Science, Helwan University.

3: Home Economics Department., Specific Education Faculty, Port Said University, Egypt.

ABSTRACT

This study aimed to investigate the protective effects of avocado and kiwi juices against cadmium-induced hepatotoxicity in male rats. Thirty-five rats were used and divided into two main groups. The first main group (n = 7) was fed on a basal diet and served as negative control. The second main group (n = 28) was fed on a basal diet for six weeks and orally administered Cadmium Chloride $CdCl_2$ (3 mg/kg b.w.) to induce hepatotoxicity. After induction rats were divided as follow: subgroup 1 served as the control positive group and 2, 3 and 4 treated rat subgroups were received 1 ml/day of 10% avocado; kiwi pulp juice; and mixed juice of avocado and kiwi (1:1), respectively. According to the results, HPLC analysis of avocado and kiwi fruits revealed several main components with strong antioxidant properties. Also, avocado fruits content was the highest in phenolic compounds (259.19 mg/100g GAE); flavonoids (2.98mg/100g CE) followed by kiwi fruits. Kiwi fruit is rich in ascorbic acid (15.50 mg/100g). Furthermore, results revealed that Cd exposure significantly elevated liver and kidney enzymes, disrupted lipid profile, and increased oxidative stress markers. Contrast, treatment with avocado and kiwi juices markedly improved these parameters, they caused a significant improve of body weight and increase liver weight, accompanied by improve in levels of liver functions, kidney function, as well as significant improve in levels of lipid profile. In addition, significantly reduced malondialdehyde, while catalase, superoxide dismutase and glutathione activities were significantly ($P \leq 0.05$) increased. These findings suggest that avocado and kiwi juices possess potent antioxidant and hepatoprotective properties and could serve as natural dietary protectants against cadmium toxicity.

Keywords: Cadmium, Antioxidant, Avocado, Kiwi, Liver function, Oxidative stress.

INTRODUCTION

Cadmium (Cd) released into the environment through human activities, such as industrial processes (e.g., metal production and battery manufacturing), mining, and agricultural practices (e.g., Cd containing fertilizers). People can be exposed to Cd through various routes, including inhalation of contaminated air, ingesting Cd-contaminated food and water, and dermal contact with Cd-containing products **(Branca *et al.*, 2018)**. Organizations like the International Agency for Research on Cancer (IARC) classify Cd as a human carcinogen. Its chronic exposure has been linked to various adverse health effects, including lung cancer, prostate cancer, and kidney disease **(Almeer et al., 2019)**. Cd damages the liver, kidneys, brain, placenta, and testicles **(Ansari et al., 2017)**. When first exposed to Cd, the liver is the main organ that absorbs and accumulates most of the Cd. Primarily, Cd binds to a sulfhydryl group on essential molecules in mitochondria. Activation of the thiol groups causes oxidative stress, mitochondrial dysfunction, and a transition in mitochondrial permeability. Secondary damage occurs after acute Cd hepatotoxicity. It deteriorates endothelial cells, resulting in hepatocellular injury. As a result, it activates Kupffer cells and neutrophil infiltration, activating cascades to induce toxicity **(Ghoneim et al., 2015)**.

Avocado (*Persea americana Mill*) belongs to the Lauraceae family and is cultivated extensively worldwide **(Anjum et al., 2024)**. Numerous studies have shown that avocado is effective in treating and preventing a variety of ailments **(Abdel-Gaber et al., 2024)**. Avocado contains terpenoids, alkanols, glycosides, flavonoids, and coumarin. It also contains persin, which has been shown to play a role in inhibiting the formation of superoxide and nitric oxide radicals in cell cultures **(Selladurai and Awachare 2020)**. The entire avocado (pulp, peel, and seed) is rich in extensive health benefits like antioxidant, antimicrobial, antidiabetic, anticancer, antifungal properties, cardiovascular health, healthy aging, and weight management **(Jimenez et al., 2021)**.

Kiwi fruit was earlier known as Chinese gooseberry. *Actinidia chinensis* and *Actinidia deliciosa* are commonly known as green and gold kiwi fruit, respectively. It is relatively plentiful source of vitamin C, vitamin E, folate, potassium, phytochemicals, and enzymes especially actinidin **(Richardson et al., 2018)**. Existing literature supports the fact that supplementation of kiwi fruit in diet can provide health benefits like improved immune, gastrointestinal, and cardiovascular functions. The consumption of an average size kiwi fruit fulfills the recommended daily allowance for vitamin C, which scavenges ROS, such as superoxide (O_2-), H_2O_2, and hydroxyl radicals (OH^-), and prevents cell damage due to oxidative stress **(Cundra et al., 2020)**. Some of the health benefits of immunity-boosting food kiwi include prevention of diabetes, cardiovascular disease, promotes digestion, increases immunity power, and progresses metabolic health **(Baranowska and Dominik 2019)**. Therefore, the present study aimed to investigate the protective effects of avocado and kiwi fruit juices against cadmium-induced hepatotoxicity in rats.

MATERIALS AND METHODS

MATERIALS:

1- **Chemicals:** Casein, cellulose, vitamins, minerals, cellulose, and cadmium were purchased from El-Gomhoria Company, Cairo, Egypt. All other chemicals used were analytical grade were obtained from Sigma-Aldrich.

2- **Avocado and kiwi** were purchased from the Agricultural Research Center in Cairo, Egypt.

3- **Kits** for blood analysis were purchased from Alkan Company for Biodiagnostic Reagents, Dokki, Cairo, Egypt.

4- **Animals:** Thirty-five adult male rats (Sprague Dawley strain) weighing (180±20) g were obtained from the National Research Center, Dokki, Egypt.

METHODS:

1- Preparation of Avocado and Kiwi Juice

Avocado and kiwi were adequately washed and peeled. The seeds were discarded to preserve the juicy part of the fruit. Avocado and kiwi pulp were homogenized in a blender using 500 g/500 ml water without sugar. The fruit juices were stored in a clean container at -20 °C.

2-Determination of Total Phenolic Compounds

Total phenolic compounds of avocado and kiwi fruits were determined spectrophotometer using Folin-Ciocalteu colorimetric method **Asami et al., (2003)**.

3- Determination of Total Flavonoids

Total flavonoids content of avocado and kiwi fruits extracts were determined by using spectrophotometer according to the method described by **Khatiwara *et al.*, (2010)**.

4- Identification of Individual Phenolic Compounds by High Performance Liquid Chromatography (HPLC)

Phenolic compounds in avocado and kiwi fruit were determined by HPLC according to the method by **Goupy *et al.,* (1999)** as follows: 5g of samples were mixed with methanol and centrifugated at 1000 rpm for 10 min and the supernatant was filtered through 0.2 Mm.

5- Identification of Individual Flavonoids by HPLC

Flavonoids compounds were determined by HPLC according to the method of **Mattila *et al.,* (2000)** as follow: 5g of sample were mixed with methanol and centrifuged at 1000 rpm for 10 min and the supernatant was filtered through a 0.2 µm.

6- Determination of Antioxidant Activity Using 2,2- diphenyle-1-picrylhydrazyl (DPPH) Radical Scavenging Method

Antioxidant activity of fruits was determined using the stable radical (DPPH) according to **Brand-Williams *et al.* (1995)**.

Experimental Design

The experimental animal study was done using (n=35) male rats, with a body weight of 180 ±20 g. The rats were housed in cages under hygienic conditions in a temperature-controlled room at 25°C. The basal diet was semi-synthetic and nutritionally adequate (AIN-93 M), and the vitamins mixture and minerals mixture were prepared as described by **Reeves et al., (1993)**. The animals were randomly divided into two main groups as follows:

The first main group (n=7) was fed on a basal diet (negative control). **The second main group (n=28)** was fed on a basal diet for 6 weeks and was administered Cd (3 mg/kg body weight daily for 2 weeks) in 0.5 ml of sterile physiological saline orally **(Shibasaki et al., 1994)**. Then, these rats were divided into four subgroups as follows:

Subgroup (1):	Rats were fed on basal diet (Positive control).
Subgroup (2):	Rats were fed on basal diet and orally given 1 ml/day of avocado pulp juice at concentration of 10%.
Subgroup (3):	was fed on basal diet and orally given 1 ml/day of kiwi pulp juice at concentration of 10%.
Subgroup (4):	was fed on basal diet and orally given 1 ml/day of avocado and kiwi pulp juice (1:1) at concentration of 10%.

Biological Evaluation

The biological evaluation of the diet was carried by determination of feed intake (FI), body weight gain (BWG %) and feed efficiency ratio (FER) according to **Chapman, (1959)** using the following equation:

$$\textbf{BWG}\ \% = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Initial body weight}} \times 100$$

FER = Weight gain (g) / Feed intake (g)

Blood Collection and Serum Separation:

At the end of the experimental period (6 weeks), rats were fasted overnight, then the blood was collected under slight ether anesthesia. Serum was separated by centrifugation at 3000 rpm for 15 minutes. The obtained serum was used immediately for routine laboratory investigation.

Biochemical Analysis:

Liver Function:

Serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were measured according to (**Bergmeyer *et al*., 1978)**, Alkaline phosphates (ALP) was determined according to **Belfield and Goldberg (1971)**.

Kidney function:

Serum urea **(Kaplan, 1984)**, uric acid **(Patton and Crouch, 1977),** and creatinine were measured according to **(Murray, 1984)**.

Lipid Profile:

Serum total cholesterol (TC) **(Richmond, 1973)**, triglycerides (TG) **(Wahlefeld, 1974)**, high density lipoprotein (HDL-c) **(Albers *et al*., 1983)** were determined. Meanwhile, low density lipoprotein (LDL-c) and very low density lipoprotein (VLDL-c) were calculated according to **Fridewald *et al*., (1972)**.

LDL-c = TC-[HDL-c + (TG/5)]　　　　VLDL-c = TG/5

- **Oxidative and Antioxidant Biomarkers:**

The plasma level of lipid peroxidation as malondialdehyde (MDA) was determined according to **Draper and Hadley (1990)**. Superoxide dismutase (SOD) activity was evaluated as described by **Spitz and Oberley, (1989)**. Catalase (CAT) was measured according to (**Aebi, 1984),** and Glutathione (GSH) were measured as the method described by **Moin, (1986)**.

Statistical analysis:

Statistical analyses were performed using SPSS computer program (Graph pad software Inc, San Diego, CA, USA). One-way analysis of variance (ANOVA) followed Duncan’s multiple tests were done P≤0.05 were significant **(Armitage and Berry, 1987)**.

Results and Discussion

Bioactive component	Avocado fruit	Kiwi fruit
Total phenolic (mg/100g)	259.19	258.57
Total flavonoid (mg/100g)	2.98	1.69
Ascorbic acid (mg/100g)	9.39	15.50
Scavenging activity of extract (sample/µg DPPH)	89.90	90.50

Bioactive components of avocado and kiwi fruit are shown in **Table (1)**. Results revealed comparable total phenolic contents in avocado and kiwi, while avocado exhibited significantly greater total flavonoids and kiwi showed significantly higher ascorbic acid. DPPH radical scavenging activity was similar between the two fruits used. These findings indicate complementary antioxidant profiles: avocado is richer in flavonoids, whereas kiwi provides more vitamin C. These results agreement with **Nguyen et al., (2022) ;Alghanam et al., (2023);** who observed that the extracts of fresh avocado fruit exposed high total phenolic, flavonoid, antioxidant activity, and ascorbic acid (258.75 mg GAE/100g, 2.89 mg CE/100g, 89.7 % and 9.35 mg), respectively. Also, **Shehata and Soltan, (2013)** revealed that the highest concentration of phenolic compound was obtained of avocado fruit (259.15 mg/100g GAE) followed by kiwi fruit (258.55 mg/100g GAE). Also, avocado fruit has higher content flavonoids and lower level of ascorbic acid compared to kiwi fruit. Avocado also possesses high levels of flavonoids in its pulp **(Sayago-Ayerdi et al., 2021)**. Moreover, **Park *et al.,* (2011)** reported the amount of ascorbic acid in kiwi fruit ranged from 6.56 to 15.2 mg/100g.

Table (1): Total phenolic, flavonoids, ascorbic acid compounds, and scavenging activity of avocado and kiwi fruits

Data in **Table (2)** showed identification of phenolic compounds of avocado and kiwi fruits by HPLC. Phenolic profiling (ppm) indicated that both fruits contained high levels of pyrogallol and catechin, but each fruit also presented unique phenolics (e.g., ellagic acid prominent in avocado; chlorogenic acid detected in kiwi). Significant differences in specific phenolic concentrations were noted. The presence of both shared and unique compounds suggests complementary antioxidant mechanisms. Recently, **Conceicao et al., (2022)** found that the different parts of avocado fruit contain numerous phenolic compounds. These results are in line with those obtained by **Negm and Abo-Raya, (2018)** who reported that protocatechuic acid was the main phenolic compound identified, followed by kaempferide and vanillic acid. In addition, clorogenic acid, syringic acid, rutin, and kaempferol were present in small amounts. Regarding kiwi fruit, **Liu et al., (2019)** showed chlorogenic acid and ferulic acid were the main phenolic compounds found in kiwi fruit. **Ragab et al., (2019)** indicated that the highest phenolic compounds of kiwi fruit recorded for pyrogallol and protocatchuic acid while, the lowest phenolic compounds of kiwi fruit recorded for coumarin and caffeic acid.

Table (2): Phenolic compounds of avocado and kiwi fruits (ppm)

Phenolic compounds	Avocado fruit	Kiwi fruit
Pyrogallol	217.55	224.54
Protocatechuic	23.30	13.87
Vanillic	3.86	4.30
Chlorogenic	-	57
Catechol	21.35	5.30
Caffeine	-	2.26
Catechin	47.76	48.60
Ferulic	2.07	-
Cinnamic	-	3.40
Coumarin	0.99	3.88
Ellagic	73.43	-

Identification of flavonoid compounds of avocado and kiwi fruit are summarized in **Table (3)**. Avocado was characterized by higher concentrations of quercetin and related flavonoids, whereas kiwi exhibited markedly elevated levels of certain rosmarinic/hesperetin-like compounds. These compositional differences likely contribute to distinct but synergistic bioactivities. These results are in line with those obtained by **Shehata and Soltan, (2013) Negm and Abo-Raya, (2018);** reported that rutin, quercitrnic and quercitin were detectable in avocado fruit and not detectable in kiwi fruit. Rosmarinic and hespererdrin were the major flavonoid in kiwi fruit (901.80 and 826.20 µg/100g). Meanwhile, narenginin was only detectable in kiwi fruit. From these results it could be noticed that the flavonoid compounds in avocado fruit were more than kiwi fruit. These results are in agreement with **Ragab et al., (2019)** indicated that the highest flavonoid compounds of kiwi fruit recorded for hespirdine and narengin while, the lowest flavonoid compounds of kiwi fruit recorded for campferol.

Table (3): Flavonoids compounds of avocado and kiwi fruits (µg/100g).

Flavonoid compounds	Avocado fruit	Kiwi fruit
Rutin	81.57	-
Rosmarinic	60.70	900.50
Quercitrinic	88.30	-
Quercitin	223.12	-
Narengnin	-	66.60
Hesperetin	175.64	-
Kampferol	61.85	-
Hespererctin	-	825.70

Recorded results in **Table (4)** interpreted the effect of avocado and kiwi juice on FBW, BWG%, FI, FER and liver weight of hepatotoxicity in rats. There was no significant difference in the initial body weight (IBW) of rats. The current study showed that Cd exposure markedly reduced FBW, BWG% and FER compared with the negative control ($P \leq 0.05$), which Cd sulfate intoxication reduced the feed consumption in rats. This finding reconciles with **Anjum et**

al., (2024) who found that the mean body weight was decreased in Cd-intoxicated rats compared to the (-ve) control. Consistent results were also reported by **Ali et al., (2025)**, who found that the intake of food was decreased in Cd rat groups. The decrease in liver weight may reflect a retardation in the body weight (BW), which is itself a consequence of reduced food and water intake and loss of appetite.

Table (4): Effect of avocado and kiwi juice on initial body weight (IBW), final body weight (FBW), body weight gain (BWG), feed intake (FI) and feed efficiency ratio (FER) of hepatotoxicity in rats

Parameters / Groups	IBW (g)	FBW (g)	FI g/d/rat	BWG (%)	FER (%)	Liver weight (g)
Control (-Ve)	166.40±1.40[a]	209.80±1.13[a]	22	26.08±0.93[a]	0.070±0.001[a]	7.89±0.01[a]
Control (+Ve) (Cd)	164.60±1.03[a]	179.20±1.88[c]	15	8.87±0.46[d]	0.035±0.001[c]	4.50±0.04[d]
Avocado juice	165.41±1.53[a]	195.80±1.67[b]	21	18.37±0.31[b]	0.052±0.001[b]	5.84±0.05[c]
Kiwi juice	162.80±1.56[a]	185.60±1.95[b]	18	14.62±0.47[c]	0.047±0.001[b]	5.60±0.05[c]
Mixture of avocado and kiwi juice	163.75±1.12[a]	203.00±1.90[a]	20	23.97±0.48[a]	0.070±0.001[a]	6.82±0.07[b]

Values are expressed as means ± SE.
Values at the same column with different letters are significantly different at P≤0.05.

On the other side, body and organ weights, in Cd sulfate-treated animals co-administered of avocado or kiwi juices significantly improved these growth parameters, and the combined treatment produced the greatest increase in FBW, BWG% and FER, approaching values of the healthy control group. This indicates a restorative effect of the supplements on appetite and nutrients utilization. This is in line with previous findings by **Abd Allah, (2020)** who observed that oral administrations of juices (kiwi juice or avocado juice) showed a significant increase ($P < 0.05$) in FI, BWG%. Also, **Naveh et al.,**

(2013) who reported that avocado consumption is associated with improved FI. Furthermore, **Chen et al., (2023)** observed that kiwi_fruit polysaccharides intervention alleviated liver damage and thereby slowly improved body weight loss. Also, **Abd-Elfatah et al., (2021)** showed that rats received diet supplemented with kiwi fruit showed significant increase ($P<0.05$) in FI, BWG%, and (FER) when compared to (+ve) control group.

The tabulated results in **Table (5)** revealed that Cd intoxication significantly elevated serum AST, ALT, and ALP activities relative to the negative control ($P \leq 0.05$). This finding reconciles with **Anjum et al., (2024)** who found the elevated serum levels of liver ALT, AST, and ALP, with Cd toxicity, indicate a loss of functional integrity of the cell membrane and cell leakage in the liver. Accumulation of Cd in the liver, either in small quantities or large amounts over time, could resulted in the dysfunctionality of the liver **(Anadozie et al., 2023)**. Liver, among other organs of the body, is the most susceptible to Cd toxicity because of its metabolic roles and the Cd-metallothionein binding protein found in liver tissues **(Al-Rikabi et al., 2021)**. On the other side, treatment with avocado or kiwi juices significantly decreased these enzyme levels, while the combined treatment achieving the most pronounced normalization. These results support the hepatoprotective effect of both juices against Cd-induced liver injury. These results agreed with **Abd Allah, (2020)** who showed that treated with high dose of avocado juice or kiwi juice showed the highest decrease in the serum levels of AST and ALT. **Al-Dosari, (2011)** who indicated that rats which consumed one or two ml/day/rat avocado extract for 70 days showed decrease in AST and ALT activities. The beneficial effect of avocado fruit may be attributed to its phenolic and flavonoids which have antioxidant properties. Furthermore, **Abd-Elfatah et al., (2021)** showed that kiwi_fruit as nutritional sources helped to bring back serum levels of AST, ALT, and ALP enzymes. Also, **Elbadrawy and Elkewawy, (2019)** revealed that, the groups were treated daily with kiwi fruit juice significant decreases in serum levels of ALT, AST, and ALP. The amelioration effects of kiwi fruit extract on hepatic toxicity may be attributed to the combination of several different mechanisms included: antioxidant activity; anti- inflammatory properties, and direct scavenge of free radicals with reduction in oxidative stress and lipid peroxidation **(Moysidou et al., 2024)**.

Table (5): Effect of avocado and kiwi juice on liver function of hepatotoxicity in rats

Parameters / Groups	AST	ALT	ALP
	(µ/L)		mg/dl
Control (-Ve)	29.02±0.42^{d}	44.17±0.61^{e}	122.44±1.89^{d}
Control (+Ve) (Cd)	53.18±0.49^{a}	90.06±0.35^{a}	168.98±1.80^{a}
Avocado juice	38.58±0.48^{b}	80.73±0.59^{b}	150.18±1.54^{b}
Kiwi juice	40.98±0.53^{b}	71.57±0.37^{c}	153.98±1.09^{b}
Mixture of avocado and kiwi juice	33.74±0.60^{c}	62.93±0.37^{d}	147.18±1.69^{c}

Values are expressed as means ± SE.
Values at the same column with different letters are significantly different at P≤0.05.

The tabulated results in **Table (6)** Cd injection induced significant increases in serum urea, creatinine, and uric acid (P ≤ 0.05), indicating renal impairment. These results agreed with **Badawy et al., (2024)** who observed that the administration of cadmium chloride for 4 and 8 weeks resulted in significant (p<0.05) increases in the serum creatinine, urea, and uric acid levels, indicating kidney dysfunction. Moreover, Cd has detrimental effects on kidney functions, and this effect is referred to its oxidative stress effect **(Negm and El-Soadaa, 2020;Adel and Ghalwash, 2022)**.

On the other side, treatment with either avocado or kiwi juices significantly ameliorated these elevations, while the combined juices led to the greatest improvement, returning renal markers closest to control values. This suggests nephroprotective properties of the treatments. These results agreed with **Abd-Elfatah et al., (2021)** elucidated that avocado or kiwi fruits decrease the elevation of uric acid and creatinine. **Abd Allah, (2020)** showed that juices of kiwi and avocado effectively improved kidney functions due to its phytochemicals compounds (phenolics and flavonoids) which play vital role against free radical that due to antioxidant and inflammatory properties. These findings are in agreement with the study of **Girma et al., (2021)** who showed that orally given avocado fruit juice improved the kidney functions as evidenced by the reduction of the elevated serum creatinine, urea, and uric acid concentrations.

Furthermore, **El-Kholie et al., (2018)** showed that 200 mg/kg kiwi fruit extract had improved liver and kidney functions compared with kiwi fruit as powder. Also, **Mahmoud, (2017)** observed that administrating kiwi significantly ameliorated the elevated kidney functions compared to gentamicin group. Bioactive compounds present in kiwi fruit highlight its profound potential from flavonoids, like quercetin and catechin, to important vitamins, such as vitamin C, E, and B, each offers a unique mechanism of action that contributes to physiological health and homeostasis **(Moysidou et al., 2024)**.

Table (6): Effect of avocado and kiwi juice on kidney function of hepatotoxicity rats

Parameters / Groups	Urea	Creatinine	Uric Acid
	mg/dl		
Control (-Ve)	27.75±2.10[c]	0.45±0.04[d]	1.52±0.12[e]
Control (+Ve) (Cd)	60.51±3.08[a]	1.68±0.05[a]	5.90±0.50[a]
Avocado juice	37.05±0.97[b]	0.70±0.06[bc]	2.60±0.27[c]
Kiwi juice	40.18±1.06[b]	0.76±0.05[b]	3.05±0.68[b]
Mixture of avocado and kiwi juice	29.68±0.58[c]	0.69±0.03[c]	2.20±0.63[d]

Values are expressed as means ± SE.
Values at the same column with different letters are significantly different at P≤0.05.

The tabulated results in **Table (7)** showed that, exposure to Cd caused a significant dyslipidemic pattern (↑TC, ↑TG, ↑LDL, ↑VLDL and ↓HDL) compared with control (P ≤0.05). These results agreed with **Negm and El-Soadaa, (2020**) who revealed that exposure of the rats to Cd caused significant distortion in the lipid profiles of the rats leading to dyslipidemia which, caused a significant increase in the serum levels of TC, LDL-C and TG while reducing HDL-C. **Yang et al., (2025)** imply that Cd causes disorders in lipid metabolism and induces liver damage, which is in line with previous study by **Liu et al., (2023)**. On the other side, administration of avocado or kiwi juices significantly improved lipid parameters, and the combined treatment showed the strongest corrective effect, restoring the lipids profile toward normal. Our results agree with **Girma et al., (2021)** who found that administration of high dose of avocado fruit juice decreased the mean serum TC and LDL-C, while increasing HDL-C in T2DM-induced rats. This results are in line with the results of **Adnan et al., (2021)** who observed that avocado juice decrease in TC, TG and LDL-C concentrations with concomitant significant increase in HDL-c. The possible mechanism by which avocado enhances HDL-c level may be due to regulating the hydrolysis of certain lipoproteins and their selective uptake, and metabolism by different tissues **(Boshtam et al., 2013)**.

Furthermore, **Popiolek-Kalisz et al., (2024)** showed that the supplementation of nutraceuticals from kiwi led to improvements in lipid profile. **Alim et al., (2023)** indicated that consumption of 2 whole kiwifruit or more significantly decreased the augmented levels of TC, TG and LDL-c augmented the reduced levels of HDL-c in High fructose-supplemented rats, indicating the beneficial effects of golden kiwifruit as a whole in improving dyslipidemia due to the phenolic and pectin components. **El-Kholie et al., (2018)** showed that 200 mg/kg kiwifruit extract had improved the lipid profile. Lipid profile reducing effect of fruit juices is due to its polyphenols, phytostanols, tocopherols and dietary fiber, which help reduce cholesterol reabsorption in the intestine and promote fecal cholesterol excretion, which in turn reduces the level of LDL-c, increasing the amount of cholesterol excreted from the body and decrease in hepatic cholesterol synthesis **(Moysidou et al., 2024)**.

Table (7): Effect of avocado and kiwi juice on lipid profile of hepatotoxicity rats

Parameters / Groups	TC	TG	HDL	LDL	VLDL
	mg/dl				
Control (-Ve)	110.15±1.90[d]	60.60±0.47[d]	40.47±0.54[a]	57.29±0.41[e]	12.12±0.09[d]
Control (+Ve) (Cd)	141.14±1.98[a]	92.16±1.44[a]	24.52±0.29[d]	98.18±0.82[a]	18.43±0.08[a]
Avocado juice	133.12±1.89[b]	73.11±0.90[b]	27.33±0.55[d]	91.16±0.50[b]	14.62±0.18[b]
Kiwi juice	132.98±1.26[b]	70.31±0.75[b]	32.24±0.72[c]	86.67±0.87[c]	14.06±0.05[b]
Mixture of avocado and kiwi juice	127.22±1.53[c]	64.64±0.83[c]	35.41±0.84[b]	78.87±1.07[d]	12.93±0.16[c]

Values are expressed as means ± SE.
Values at the same column with different letters are significantly different at P≤0.05.

The tabulated results in **Table (8)** showed that, Cd intoxication significantly raised MDA levels ($P \leq 0.05$) while, reduced antioxidant defenses (GSH, SOD, and CAT) evidencing pronounced oxidative stress. These results agreed with **Adel and Ghalwash, (2022)** who reported that, Cd led to high MDA levels, demonstrating lipid peroxidation along with an extreme reduction in antioxidant GSH, SOD, and CAT, reflecting the loss of a defense mechanism against oxidation. These data collectively represent a state of oxidative stress. Oxidative stress was proven to be the main player contributing to Cd toxicity as ROS accumulation disrupts cellular equilibrium, resulting in damage to numerous cell components. **Anjum et al., (2024)** confirmed previous reports that the concentration of SOD and CAT was down-regulated in the Cd-treated group. On the other side, treatment with avocado or kiwi significantly lowered MDA, while restored antioxidant enzyme activities with the combined treatment producing the most marked recovery. These data indicate that the fruit juices mitigate Cd-induced oxidative damage *via* enhancement of endogenous antioxidant systems. This result is in line with **Akeel et al., (2025)** who showed that, the treatment of Cd-exposed rats with avocado extract revealed a pronounced return to normalcy of the oxidative stress markers, as evidenced by a remarkable decrease in the testicular MDA and an improvement of SOD, CAT, and GSH activities. *P. americana* pulp extract has a potential ameliorative role against cadmium-induced oxidative stress. Similar, **Elsadek and Alquraishi, (2023)** proved that, the intake of avocado juice or powder supported non-significantly the increase of the normal activity of antioxidant enzymes, thereby removing the free radicals, by activating the detoxification/ defensive processes within the body, thus due to its bioactive flavonoids and polyphenolic compounds. Moreover, **El-Demerdash et al., (2024)** observed that supplemented orally with kiwifruit aqueous extract (KFE; 1 g/kg/day) for one month—were accompanied by decreased lipid peroxidation, while antioxidant enzymes and GSH were increased. This result is in line with **Alim et al., (2023)** showed that the administration of two whole golden kiwifruits for 4 weeks significantly ameliorated lipid peroxidation in healthy rats. Also, **Abd-Elfatah et al., (2021)** elucidated that dried kiwi fruit caused a decrease in the elevation of MDA in liver tissue which may be due to its antioxidant and anti-inflammatory activities, which linked to its bioactive substances, such as polyphenols, flavonoids, carotenoids, and vitamin C **(Moysidou et al., 2024)**.

Table (8): Effect of avocado and kiwi juice on oxidative stress and antioxidant biomarkers of hepatotoxicity rats

Parameters / Groups	MDA	CAT	SOD	GSH
	ng/mL	U/ml		nmol/mg
Control (-Ve)	110.38±1.33[e]	52.74±0.38[a]	2.94±0.21[a]	4.23±0.04[a]
Control (+Ve) (Cd)	297.39±2.15[a]	24.39±0.05[d]	1.63±0.26[d]	2.03±0.03[d]
Avocado juice	182.81±1.50[c]	42.92±0.27[b]	2.57±0.30[b]	2.98±0.03[c]
Kiwi juice	222.41±1.55[b]	38.88±0.29[c]	2.38±0.18[c]	2.85±0.16[c]
Mixture of avocado and kiwi juice	136.34±1.77[d]	45.64±0.33[b]	2.69±0.20[b]	3.74±0.60[b]

Values are expressed as means ± SE.
Values at the same column with different letters are significantly different at P≤0.05.

CONCLUSION:

This study demonstrated that cadmium exposure causes significant liver damage in rats, including elevated liver and kidney enzymes, disrupted lipid profiles, and increased oxidative stress. The results showed that administration of avocado and kiwi juices, individually or combined, effectively alleviated these harmful effects, with the combined juice providing the strongest protective effect. These findings suggest that avocado and kiwi juices possess potent antioxidants and hepatoprotective properties, making them a natural option for protecting against cadmium-induced liver injury.

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التأثيرات الوقائية لعصير الأفوكادو وعصير الكيوي ضد التسمم الكبدي الناجم عن الكادميوم في الفئران

ندى حسن شيخون [١] ، أحمد على أمين [٢] ، شيماء حسن نجم[٣]

١- قسم التغذية وعلوم الاطعمة ، كلية الاقتصاد المنزلى ، جامعة حلوان ، مصر.
٢- كلية علوم التغذية ، جامعة حلوان.
٣- قسم الاقتصاد المنزلى ، كلية التربية النوعية ، جامعة بورسعيد ، مصر.

الملخص العربي

هدفت هذه الدراسة إلى التحقيق في التأثيرات الوقائية لعصائر الأفوكادو والكيوي ضد السمية الكبدية الناجمة عن الكادميوم في ذكور الفئران. تم استخدام خمسة وثلاثين فأرًا وقسموا إلى مجموعتين رئيسيتين. تم تغذية المجموعة الرئيسية الأولى (ن = ٧) على نظام غذائي أساسي وكانت بمثابة ضابطة سالبة. تم تغذية المجموعة الرئيسية الثانية (ن = ٢٨) على نظام غذائي أساسي لمدة ستة أسابيع وتم إعطاؤها عن طريق الفم ($CdCl_2$) ٣ملجم / كجم من وزن الجسم) لإحداث السمية الكبدية. بعد الاحداث، تم تقسيم الفئران على النحو التالي: المجموعة الفرعية الاولى كمجموعة ضابطة موجبة وتلقت المجموعات الفرعية ٢ و٣ و٤ من الفئران المعالجة ١ مل/ يوم من ١٠٪ أفوكادو وعصير الكيوي وعصير مختلط من الأفوكادو والكيوي (١:١) على التوالي. وفقًا للنتائج، كشف تحليل كروماتوجرافي لفاكهة الأفوكادو والكيوي عن عدة مكونات رئيسية ذات خصائص مضادة للأكسدة قوية. كان محتوى فاكهة الأفوكادو الأعلى من حيث المركبات الفينولية (٢٥٩,١٩ ملجم/١٠٠ جرام من GAE)؛ والفلافونويدات (٢,٩٨ ملجم/١٠٠ جرام من CE)، تليها فاكهة الكيوي. بينما كانت فاكهة الكيوي غنية بحمض الأسكوربيك (١٥,٥٠ ملجم/١٠٠ جرام). علاوة على ذلك، كشفت النتائج أن اعطاء- الكادميوم أدى إلى ارتفاع ملحوظ في إنزيمات الكبد والكلى، واضطراب في مستوى الدهون، وزيادة في علامات الإجهاد التأكسدي. على النقيض من ذلك، أدى العلاج بعصائر الأفوكادو والكيوي إلى تحسين هذه المعايير بشكل ملحوظ، مما أدى إلى تحسن كبير في وزن الجسم وزيادة في وزن الكبد، مصحوبًا بتحسن في مستويات وظائف الكبد والكلى، بالإضافة إلى انخفاض كبير في مستويات صورة دهون الدم، بينما سُجلت زيادة كبيرة في اللبوبروتينات عالية الكثافة. بالإضافة إلى ذلك، انخفض بشكل ملحوظ نشاط المالونديالدهيد، بينما زاد نشاط الكتاليز، والسوبر أوكسيد ديسميوتيز، والجلوتاثيون بشكل ملحوظ ($P \leq 0.05$). تشير هذه النتائج إلى أن عصائر الأفوكادو والكيوي تمتلك خصائص قوية مضادة للأكسدة وحماية الكبد، ويمكن أن تكون بمثابة أغذية وقائية طبيعية ضد سمية الكادميوم.